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THE INSTITUTION OF ELECTRICAL ENGINEERS

JOURNAL

VOLUME 4 NO. 48 DECEMBER 1958

VOLUME 4 NUMBER FORTY-EIGHT DECEMBER 1958

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* TEMPLE BAR 7676 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

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Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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STUDENT APPRENTICESHIP

ONE OF THE FEATURES WHICH DISTINGUISHES man from the animal world is his ability to think in abstract terms and, by means of definitions, to convey his thoughts to his fellows. The process of definition is not always possible, and to cover our resultant confusion the psychologist refers to the gestalt: though we find difficulty in defining a chair, we sit in one effortlessly.

Attempts have been made in these pages and elsewhere to define 'student apprentice', and the working definition has been: one who follows a concurrent programme of academic education and industrial training. The academic part of the student apprenticeship follows a logical order, leading from a study of the basic sciences, through a detailed study of general electrical phenomena, to a measure of specialization in one of the branches of electrical engineering.

The arrangement of training follows a similar progression, beginning with basic training in the use of tools, in fabrication and in materials, followed by a programme of assembly, construction and testing work, and leading to specialized, and perhaps responsible, functional training. It is being increasingly realized that professional standards dictate that student apprenticeship should be on a sandwich basis, the students spending alternate half-year periods in industry and at college.

The success of a sandwich course depends, as was emphasized in the recent Report on the Education and Training of Student Apprentices, on the development of close co-operation and mutual understanding between college and industry. Both partners have a responsibility for their own aspect of the student apprenticeship. They also share the more important responsibility for welding the apprenticeship into a coherent whole; it is by the acceptance of this responsibility that the alternate periods of training and education become a student apprenticeship.

Perhaps the first direction in which this responsibility might be exercised is in the selection of boys for student apprenticeship. It would be unfortunate if the apprentices were to be drawn entirely from the ranks of those unable to secure admission to a university. It is believed that there is a type of boy who would benefit more from student apprenticeship than from a university career. Methods must be developed which will enable him to be detected.

Having been selected, he must not be led to regard his industrial periods as a vacation from college nor his college periods as a return to refinement. His industrial training should illustrate and extend the principles learnt at college. In at least the early stages of his apprenticeship, he should, in a sense, learn the facts in industry and the reasons at college. It is not possible to say in the abstract whether the industrial fact should precede or follow the academic reason. This is a point which could fruitfully be discussed in detail between the guiding partners in the student apprenticeship. Industry should never lose an opportunity to bring alive the student's theoretical knowledge; in fact, these opportunities should actively be sought. It is a salutary experience for each student when he realizes that the calculus works in industry as well as in the class-room.

Colleges should review continuously the syllabus content of their courses, and the treatment of the syllabus, in the light of current industrial practice. They should be prepared to prune enthusiastically, though with discrimination as some industrially obsolete material has educational value and outstanding historical interest. The essential point is to persuade the student that his college work is meaningful in an industrial context.

The primary responsibility for integrating the two parts of a student apprenticeship must fall on the industrial training officer and the head of the college department concerned. Other professional engineers will make contact with the student in the course of the apprenticeship. They can assist by making available their intimate knowledge of the industrial organization and the college and by offering constructive suggestions concerning the details of training and education.

The student's work at college covers a range of sciences and technologies, and within his principal technology—electrical engineering—his studies will be deep and extensive. In a large industrial organization, it may be possible to give the appropriate range of training. In a small or specialized organization, this is unlikely. In these circumstances, better training could be given by a group of such organizations acting together. A conference on this subject, attended by representatives of 75 specialized electrical organizations and 36 major colleges of technology, was held recently in the Institution building.

The organizational problems of student or graduate apprenticeship, perplexing in large unified electrical organizations, become formidable in group schemes. Success, involving as it does the surrender of some of the individual sovereignty of the participating organizations, depends on their common goodwill towards the training scheme. Their goodwill finds expression in their willingness to enter into a formal and binding agreement, the conduct of the training being left in the hands of an independent organizer.

The importance of the development of group training schemes cannot be overstressed. Without the material addition to practical training facilities which they alone can provide, it seems possible that specialized, and particularly smaller, firms in the electrical engineering industry will find the recruitment of professional electrical engineers difficult, thus seriously inhibiting their efforts to maintain themselves in an increasingly competitive international market. Thorny though the problems of group training may be, they can be overcome.

Higher Technological Award

THE National Council for Technological Awards have now been operating for three years. As a result of their labours, 34 young men who have successfully completed a course of study at the Birmingham College of Technology have been awarded the Diploma in Technology (Engineering)—significantly in electrical engineering.

While it is clearly too early to forecast the ultimate standing of the Dip.Tech.(Eng.), it is noteworthy that, by and large, the universities are prepared to admit diplomates to courses leading to higher degrees on an equal footing with graduates. This seems to stabilize the academic level of the Dip.Tech.(Eng.). Industrial support for Dip.Tech. courses is manifested by the 1786 students now reading for the diploma.

The National Council have now announced preliminary details of a higher award. This will take the form of Membership of the College of Technologists (M.C.T.). Initially, the Court of this College will be the National Council under another name, but later it will include representatives of Members of the College.

The award will be open to holders of the Dip.Tech. or Dip.Tech.(Eng.) and to others with an equivalent qualification, e.g. an appropriate degree. The M.C.T. differs from a master's degree or a doctorate in that it will normally be awarded for a programme of work successfully carried out in industry and at a college. The programme may be concerned with any technological aspect of industrial activity, but the problem should arise out of the diplomate's work in industry and necessitate study beyond the standard of the Dip.Tech.

The work is expected to take three years, and it is anticipated that there will be an interval between the award of the Dip.Tech. to a student and the start of his work for the M.C.T. Supervision will be provided jointly by a staff member of the industrial organization and a staff member of the college. Though the college will normally provide only facilities for advanced study, some research work may also be undertaken at college in appropriate cases.

To encourage teachers to qualify for the M.C.T., the National Council indicate their willingness to award Membership solely on the basis of a programme of work carried out at a technical college, though an industrial link would be encouraged.

Apart from providing a mark of distinction to outstanding diplomates and graduates, it is hoped that the award will be a means of fostering the investigating spirit in industry. As such, it will be widely welcomed.

Relief from Income Tax—Section 16, Finance Act, 1958

THE attention of members is directed to the brief announcement published on p. 629 of the November *Journal* which, for speed and convenience, reproduced the phraseology of the communication received from the Commissioners of Inland Revenue, itself based on the terms of Section 16 of the Finance Act, 1958. However, the Section is drawn so as to cover a number of types of societies with objects of a different kind from those of The Institution, and members will realize that the activities of some of these are far wider in scope than those which The Institution, acting within the terms of its Royal Charter of Incorporation, can properly undertake.

Members are reminded that The Institution is derived from the Society of Telegraph Engineers, formed in 1871 with the object of 'The General Advancement of Electrical and Telegraphic Science'. Its objects are now stated quite simply in the Royal Charter, granted in 1921, as being 'to promote the general advancement of Electrical Science and Engineering and their applications and to facilitate the exchange of information and ideas on those subjects'. The Royal Charter illustrates a variety of activities by means of which this end can be achieved, such as holding meetings and exhibitions, distributing communications, maintaining a library and making grants for the purpose of promoting invention and research. The Institution is precluded from any corporate action with respect to the remuneration or other personal profit of its members. The announcement to which reference has been made above must be read in this context.

Members must obtain from their local Inspector of Taxes a copy of form P358, and they will notice that, in so far as The Institution is concerned, the second only of its two 'boxes', which refers among other things to approved learned societies, should be completed before the form is returned to the Inspector.

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ATOMIC CLOCKS

The successful development of atomic clocks during the last few years has made scientists turn from the sky to the atom for the ultimate source of time measurement. Dr. Louis Essen, of the National Physical Laboratory, has done more than anyone else in Britain to develop them, and in this article he describes the N.P.L. caesium standard and other types of atomic clock. The article is based on a lecture, entitled 'The Atomic Clock', which he delivered at the meeting of the Measurement and Control Section on the 25th March and to the Rugby Sub-Centre on the 22nd October. He is to give the lecture again, to the North-Western Measurement and Control Group, on the 20th January 1959.

L. ESSEN, D.SC., PH.D., ASSOCIATE MEMBER

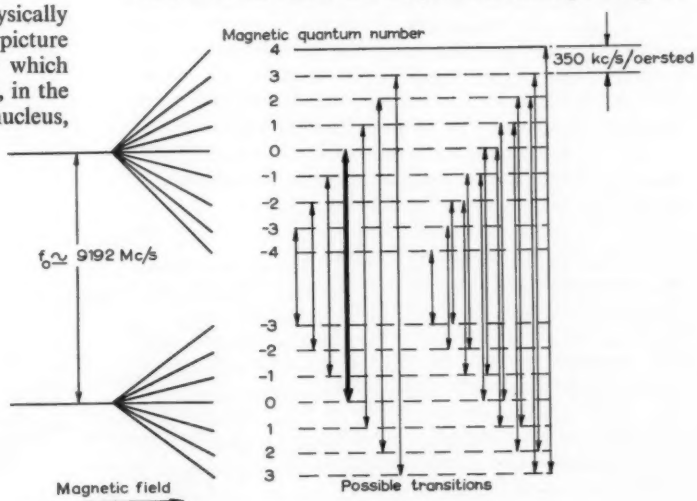
ABOUT 12 years ago, during a discussion before the Radio Section on a paper by C. F. Booth and F. J. M. Laver,* Sir Harold Spencer Jones paid tribute to the part being played by quartz clocks in the determination of astronomical time. They were designed in the first place to give a shorter interval of time than the pendulum clocks and thus to facilitate the measurement of radio frequencies; but it was soon found that they were superior to the pendulum, and it has more recently been shown that for periods of a year or so they can give a more uniform performance than the earth itself. The clocks are thus used to average out the irregularities in the earth's rotation and to give an improved time scale known as universal time 2 (U.T. 2).

This performance was not achieved without a good deal of effort, and many who, like myself, have been concerned with quartz standards will know of the precautions that had to be taken, the careful mounting, the temperature control, the design of circuit, and the monitoring of all the conditions of operation. It was with considerable excitement that Mr. J. V. L. Parry and I made the first tests on the caesium standard and found that we could shake it, play a blow-lamp on it, and alter many of the external parameters, all without causing a change of frequency exceeding 1 part in 10^{10}.

Principle of the Caesium Standard

Although they would not claim that it is physically accurate, mathematical physicists have given a picture which enables us to visualize the processes by which energy is radiated and absorbed. We can imagine, in the case of the caesium atom, a central spinning nucleus, surrounded by a cloud of electrons and then by a single valency-electron, which may be spinning in the same direction as the nucleus or in the opposite direction. According to the direction of spin, the energy of the atom is slightly different, and a transition from one state to the other will be accompanied by an absorption or emission of radiation at a frequency of approximately 9·2Gc/s. Moreover, in consequence of the electron spin, the atom behaves as a magnetic dipole, the sign of the moment depending on the direction of the spin. A magnetic dipole can be deflected in a non-uniform field, and as the deflections will be in opposite directions for the two states, we have a means of detecting when transitions occur without having to measure the very small amount of radiation involved.

There is one complication which has a considerable bearing on the choice of experimental conditions. The two energy levels are split into a number of components by a magnetic field, as shown in Fig. 1. These Zeeman levels, and therefore the frequencies corresponding to

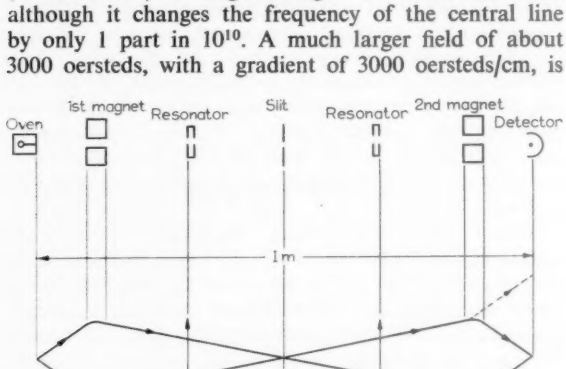


1 *Hyperfine-structure energy levels and transitions for caesium*

The transition used is shown by a heavy line

* *Journal I.E.E.*, 1946, 93, Part III, p. 236

transitions between them, now depend upon the field, but there is only a small second-order effect for the transition between the central levels. It is this transition which is employed for the standard, and the field used (0·05 oersted) is large enough to resolve the lines although it changes the frequency of the central line by only 1 part in 10^{10}. A much larger field of about 3000 oersteds, with a gradient of 3000 oersteds/cm, is



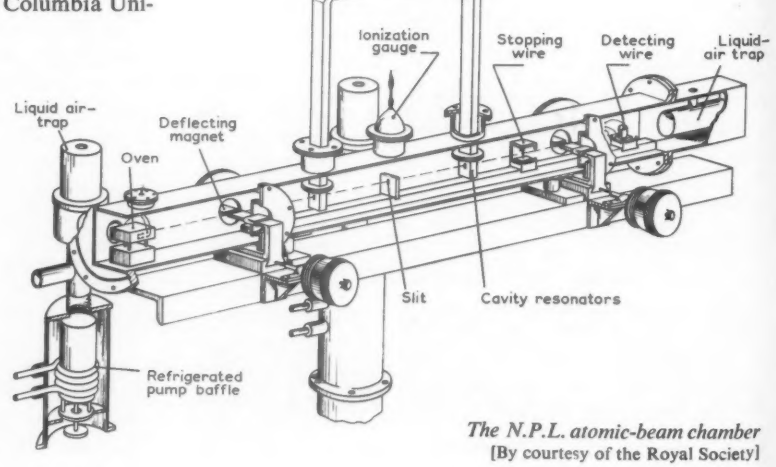
2 *Layout of components in the N.P.L. caesium standard and the path of the atoms (with deflections greatly magnified)*

required to produce the deflection. This is because the moment for the two states concerned increases with the field, and the deflection is proportional to the product of the moment and the field gradient.

Experimental Arrangement

It is well known that, if atoms are moving and colliding in a random way, transitions between two energy levels no longer take place at a single discrete frequency but over a band of frequencies. Even the sharpest optical spectral line, for example, would be far too wide for our purpose. The object must be to examine the atoms individually, as it were, while they are moving in a single specified direction. The scheme used is known as the atomic-beam magnetic-resonance method and was introduced by Rabi, Kusch and Zacharias at Columbia University for the purpose of measuring atomic magnetic moments. Fig. 2 shows the disposition of the apparatus. Atoms stream from the oven slit into a highly evacuated space and follow paths determined entirely by the magnetic deflections and the geometry of the system. The central slit selects those atoms having a suitable initial direction, velocity and moment. The second magnet deflects the atoms further in the same direction if they still have the same moment; but if transitions have been induced in the path between the magnets the atomic moments are reversed, and the atoms are deflected in the opposite sense to the detector. The transitions are induced by an alternating magnetic field in two cavity resonators, and the operation of the standard consists in varying the frequency of alternation until a maximum number of atoms reaches the detector. The frequency is then measured in terms of the quartz standard. The detector consists of a hot tungsten wire from which the caesium atoms are boiled off as positive ions and drawn to a collecting plate. The caesium atom is one of the few that can be detected so simply by a tungsten wire, and this is one of the reasons for choosing it. Another is the very suitable frequency of the resonance, the 9 Gc/s region being, from the point of view of electronics, one of the most convenient in the whole spectrum.

Apart from the convenience of this experimental arrangement there are three points of fundamental importance. In the first place, effects due to collisions are eliminated, any atoms that undergo collisions being deflected out of the path and taking no further part in the measurement. Then the field producing the transitions is at right angles to the path of the beam, and the frequency of the transition is not altered by the Doppler effect. Finally, since there is a steady flow of atoms there are no saturation effects. The three effects usually responsible for broadening spectral lines are thus inoperative, and the line width is determined solely by the length of time spent by the atoms in the field. With the arrangement we have at present this is about 2 millisec, and the width of the curve at half-power points is 300 c/s. Some of the constructional details are shown in Fig. 3. It was important that in this experimental model there should be facilities for altering all the parameters that might be suspected of causing a change in the peak of the resonance, and micrometers are provided for moving the magnets, the oven and the detector across the direction of the beam and for adjusting the width of slit.



The N.P.L. atomic-beam chamber
[By courtesy of the Royal Society]

Electronic Circuits

There are a number of circuits for providing stable supplies for the various magnets and heaters, including the oven and detector wire, but these are straightforward and require no description. The circuits for producing the exciting alternating magnetic field and for measuring its frequency when set to the optimum value are, on the other hand, as important as the beam chamber itself and required careful design. The scheme used is shown in Fig. 4.

There are altogether 15 resonances of the atoms at frequencies near the central value, and it was therefore essential for this reason alone that the exciting source should be free from modulation or sidebands. As is well known, it is not easy to eliminate all the sidebands produced by a complicated process of synthesis, and it was therefore decided to use only straightforward multiplication from a suitably adjusted quartz crystal. The crystal is mounted on a rack near the beam chamber, and its frequency is adjusted by a fine control until its multiplied output is exactly equal to that of the caesium spectral line. Now obviously we cannot expect an adjustable rack-mounted standard to be stable to 1 part in 10^{10} for very long, so its frequency is measured in terms of our primary standards in a time of 1 sec. It does not matter if sidebands are present in the measuring signal, but if a precision of 1 part in 10^{10} is to be achieved the bandwidth of the required component must not exceed 1 c/s, and precautions have to be taken in order to achieve this. The source exciting the resonance is mixed with a frequency synthesized from the standard and the small residual difference measured on a counter. The procedure, therefore, is to set the exciting source to give a maximum response of the atomic beam, to press the counter button and read off the answer. This is repeated 12 times, which takes 5 or 10 min.

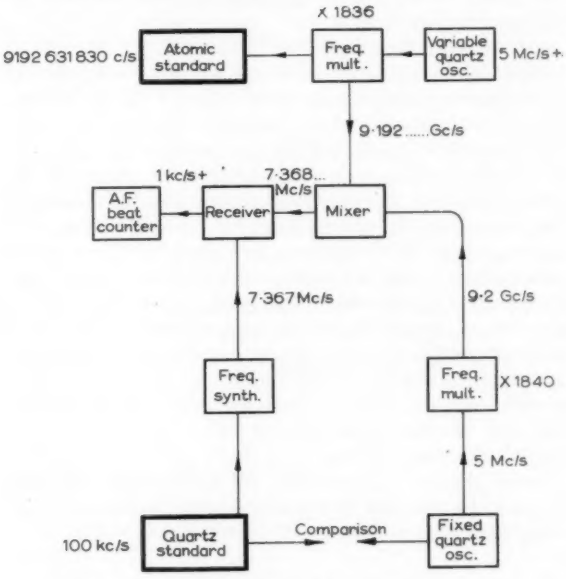
Having established that the standard deviation of the measurement outlined above was ± 1 part in 10^{10}, it was necessary to study the effect of varying all those parameters of the equipment which might vary in practice. In brief, the result of the investigation was that the only two factors which need careful definition are the value of the d.c. magnetic field and the phasing of the two cavity resonators. Both of these can be checked by the standard itself, and it is believed that the effect of accidental variation is not more than a few parts in 10^{11}. In the method of operation which has been described, the caesium standard is used simply as a resonator. This is probably the most reliable method at present, and the arrangement of apparatus which has been used is quite convenient in an institution already equipped with quartz standards.

Servo Circuits

Many radio engineers will, however, say that any process that can be operated manually can be operated better by a servomechanism, and I have no doubt that they are correct, if sufficient trouble is taken. Many future users of atomic standards will certainly require this feature and will want the standard to supply convenient frequencies, probably in a decade scale of 1 Mc/s downwards. A servo must therefore be designed which will not result in any loss of accuracy and may even improve the present accuracy of 1 part in 10^{10}. The caesium clock made in the United States, the Atomichron, is provided with a servo and has already reached a high standard of performance.

Calibration of Quartz Clocks

Let us consider now in a little more detail how the caesium resonance is used at the National Physical Laboratory as the standard of frequency and time. It has been explained that the quartz clocks are calibrated in a time of about 5 min with a precision of 1 part in 10^{10}. The calibration can be repeated as often as is desirable,



4 *Excitation of the resonance and measurement of its frequency*

taking into account the uniformity of the clock performance; and this has been examined critically not only by comparing one clock with another but also by measurements in terms of the caesium standard throughout the day and longer periods. It is very seldom that linear extrapolation of the clock rate for a period of one week would result in an error of as much as 1 part in 10^{10}, and we have therefore adopted the practice of making one routine calibration per week. Allowing for the error due to a change in the behaviour of the clock, this gives us an over-all possible error of ± 2 parts in 10^{10} in the clock frequency at any time. The accuracy of 2 parts in 10^{10} is thus obtained from an observational time of 10 min per week. Those knowing the details of astronomical determinations will appreciate the

enormous advantage of the atomic standard from the point of view of convenience alone, quite apart from the advantages of the higher accuracy and the elimination of corrections applied retrospectively.

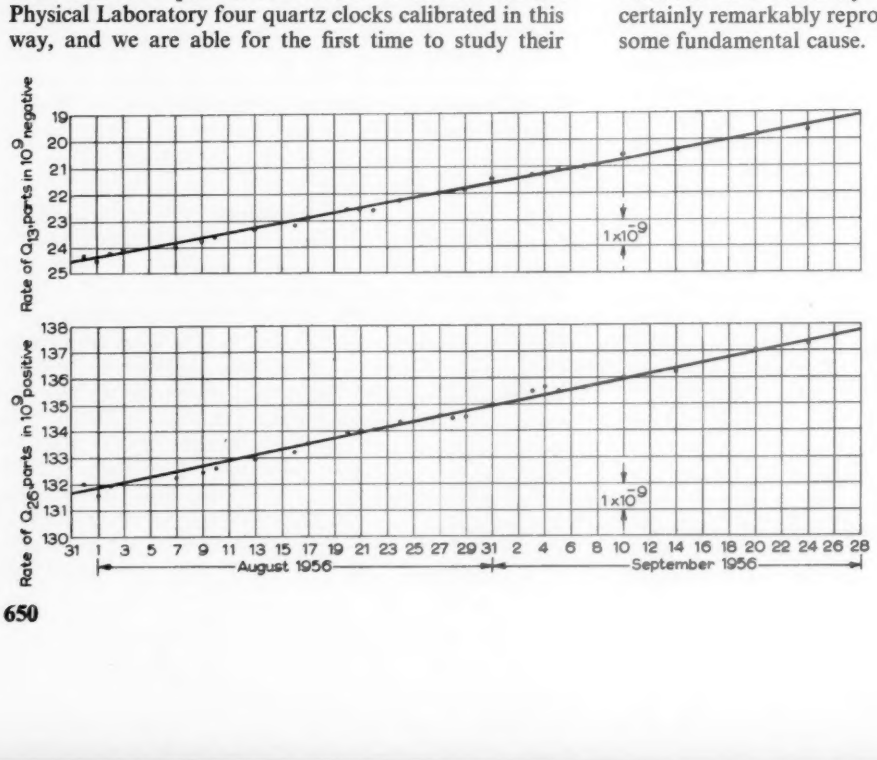
A typical set of results on which our procedure was based is reproduced in Fig. 5, which shows the frequencies of two of the quartz clocks in terms of caesium during August and September 1956, when measurements were made in a purely routine fashion by two different observers. It should be mentioned that for our calibrations we assigned a provisional value to the caesium frequency based on the value in terms of the Greenwich time signals during the first month of operation. This was in fact the only way of realizing full use of the precision it gives. Any results obtained in terms of this provisional value can be adjusted later to correspond to any other value which may ultimately be adopted by international agreement.

At present, therefore, the frequencies of the quartz standards are expressed in the unit of time corresponding to a caesium frequency (at zero field) of 9 192 631 830 c/s. The deviations of the two standards, Q_{26} and Q_{13}, from the nominal value of 100 kc/s are shown in the diagram, in which straight lines have been drawn through the observed points. It will be noticed first that the maximum departure from the straight lines was one of 2 parts in 10^{10} for Q_{26} on the 4th September. Any departure even of this amount is investigated, and it was concluded in this case that since Q_{13} showed no such departure there was a short-term irregularity in the performance of Q_{26}. This kind of effect is unusual, changes in the clocks generally appearing as changes in the rate of change of rate which persist for some weeks or months rather than as sudden changes of rate. One or two other points deviating slightly from both lines may indicate an error of calibration of about 1 part in 10^{10}. We have at the National Physical Laboratory four quartz clocks calibrated in this way, and we are able for the first time to study their behaviour in detail. From time to time changes of acceleration occur which are much larger than would be expected from the average long-term performance of the clocks, and it should be possible to determine what is causing them.

The quartz clocks are used for time and frequency measurements at the N.P.L. and also for monitoring the MSF standard-frequency transmissions radiated from Rugby by the Post Office. The frequencies are now maintained within ± 5 parts in 10^9 of their nominal values, and corrections in terms of the caesium standard to a precision of 1 part in 10^9 are published monthly. More precise corrections can be obtained from the N.P.L. for special purposes. In this way atomic time has been made available throughout the world.

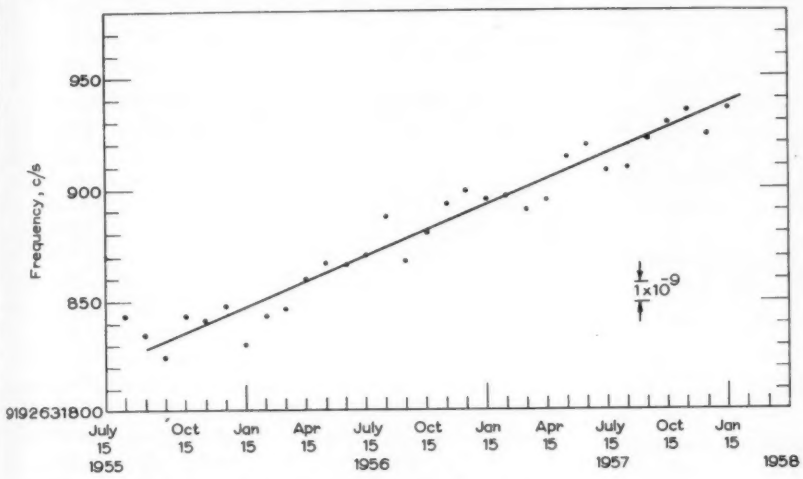
Variations in Mean Solar Time

The N.P.L. atomic standard has been used to measure both periodic and irregular variations in the rate of rotation of the earth. A variation with an approximately annual period had already been detected by a study of quartz-clock results. A statistical analysis of the results obtained with a group of clocks enables the average drifts and accelerations to be eliminated, and it is then found that there is a residual periodic variation which is fairly constant from year to year. A correction is made for this variation in the computation of the time scale U.T.2, and the results obtained with the caesium standard during the past three years confirm this correction term very closely. The earth regarded as a clock becomes approximately 30 millisec fast and slow during the year. The effect is usually attributed to seasonal movements of air layers on the surface of the earth; but Lanchester, in 1935, predicted that an annual periodic variation in the rate of rotation of the earth might possibly be observed as a relativity effect. The observed effect is certainly remarkably reproducible, leading one to suspect some fundamental cause.



5 *Rates of quartz clocks Q_{13} and Q_{26} for August and September 1956*

A new unit of astronomical time, called simply the second, has been introduced because of this periodic and other irregular variations in the period of the earth's rotation. This new unit is best determined by observation of the orbital motion of the moon and must be averaged over a number of years if an accuracy to 1 part in 10^9 or better is required. It is clearly important to determine the second in terms of the caesium resonance, and there is a joint programme of comparison between the U.S. Naval Observatory and the National Physical Laboratory for this purpose. The results are first expressed in the time scale U.T.2, and they show how this has changed since June 1955.* The departures from the straight line in Fig. 6 are, since September 1955 at any rate, no more than the errors of the two determinations, so that, compared with caesium, the second of U.T.2 has been increasing uniformly at the rate of about 5 parts in 10^9 per year. The results also provide evidence of the accuracy with which U.T.2 can be determined by means of astronomical observations made with photographic zenith tubes, together with quartz clocks. The clocks used were of the ring type made by the British Post Office.



6 *Frequency of the caesium resonance in terms of U.T.2*

Masers

This article would not be complete without some reference to the frequency standards known as masers, because, although the transition is between two configurations of the ammonia molecule, they are often rather loosely termed atomic clocks. Any atomic or molecular transition is a potential standard of frequency, and the choice depends on practical considerations. A particular spectral line of the ammonia inversion spectrum [the (J = 3, K = 3) line] is attractive because it is by far the most intense line found in the r.f. spectrum. If energy at a frequency of 23·87 Gc/s is transmitted along a waveguide containing ammonia at a low pressure, a very marked absorption can be detected. The absorption line is broadened by all the factors mentioned earlier, and it was clear that it would be of little use as a standard unless a fundamentally different technique could be developed. This was achieved by Gordon, Townes and Zeiger at Columbia University and Basov and Prokhorov in the Soviet Union. A unidirectional beam of molecules is used, as shown in Fig. 7, and those in the low-energy state are removed from the beam by an electrostatic deflection. Those remaining stream into a cavity resonator, where they liberate their energy to give a detectable microwave emission signal. The smallest frequency width of the signal obtained is about 10 times greater than that of the caesium standard, and the centre frequency is pulled to some extent by the cavity resonator and by external parameters. It is rather difficult, therefore, to determine the undisturbed frequency of the ammonia line. The first precise measurements were made by Bonanomi and Hermann at Neuchatel, who gave the value:

$$f = 23\,870\,129{\cdot}42 \pm 0{\cdot}05 \pm 0{\cdot}12\ \text{kc/s}$$

They studied the effects of the various parameters and later adopted a somewhat complicated experimental technique for arriving at the true frequency with an accuracy within about ± 1 part in 10^9. The value used for monitoring the Neuchatel time signals is:

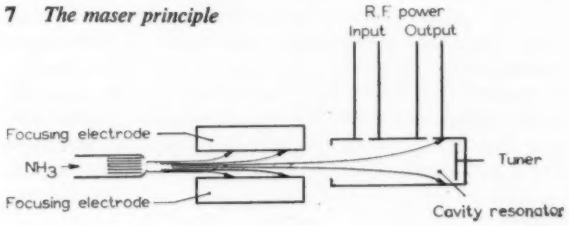
$$f = 23\,870\,129{\cdot}235\ \text{kc/s}$$

It has recently been found that the (3, 3) line consists of a number of components and that the (3, 2) line may be more suitable in spite of its lower strength.

Intercomparison of Atomic Standards

Although the basis of the atomic standard is a fundamental physical constant, it is important to compare the frequencies of standards made in different ways or at

7 *The maser principle*



* Essen, L., Parry, J. V. L., Markowitz, W., and Hall, R. G.: 'Variation in the speed of rotation of the Earth since June 1955', *Nature*, 1958, **181**, p. 1054

different institutions in order to check the techniques by which the information is extracted from the atom. So many changes have been made to the experimental model at the N.P.L. that, in effect, many different standards have been compared and have been shown to agree to ± 2 parts in 10^{10}. For these comparisons it was necessary to assume that the group of quartz clocks could be relied upon for a few days, but we have recently put into operation a simpler standard, though exactly similar in principle; and this new standard agrees with the old one to the same precision. Distant standards can be compared by means of standard-frequency transmissions and time signals, and the N.P.L. standard has been compared with an Atomichron operated in New York by this method. The Atomichron was used to monitor a transmission on 95 kc/s which was received and measured by Pierce at Harvard, who was also making regular measurements of the MSF and GBR transmissions. The results,* summarized in Table 1, represent a very considerable step forward in the international comparison of standards.

Table 1. Frequency difference between the N.P.L. caesium standard at Teddington and an Atomichron in New York

Date	Monthly average values of frequency differences Unit = 1 part in 10^9		
	MSF (60 kc/s) —N.P.L. Cs	GBR (16 kc/s) —Atomichron	Atomichron —N.P.L. Cs
November 1956..	−0·8	−0·1	−0·7
December 1956..	0	+0·2	−0·2
January 1957 ..	+0·5	+1·1	−0·6
February 1957 ..	+1·6	+2·4	−0·8
March 1957 ..	+2·4	+2·9	−0·5
April 1957 ..	+3·8	+3·8	0
May 1957 ..	+3·2	+3·4	−0·2

Standard deviation of individual daily measurement, ±0·4

Note. MSF and GBR were controlled by the same quartz standard

In order to obtain these results a careful study was made of the propagation characteristics over the different paths, and it is believed that the effects of small diurnal variations have been eliminated. It is possible that there is a small systematic effect, but it is estimated that this should not exceed a few parts in 10^{10}. The results demonstrate, therefore, that the two standards, made quite independently and of very different construction, agree within 1 part in 10^9 and that comparisons of time and frequency over great distances can be made with a precision of a few parts in 10^{10}. These frequency comparisons are made by observations extending over a short time—perhaps 10 min under good conditions—but the standards may also be compared by the use of time signals (or seconds pulses superimposed on standard frequency transmissions) if at each station the time scale is linked with the standard. The signals must be observed over several months for a precision of 1 part in 10^{10}, and such comparisons are now in progress between the U.S. Naval Observatory and the National Physical Laboratory. Since July 1957 the Neuchatel signals have been expressed in terms of a maser as well as U.T.2, and corrections are also published for MSF as received at Neuchatel. By means of these corrections we are able to infer that in the period July–October 1957 the maser changed relatively to the caesium standard by 4 parts in 10^9, if the propagation and comparison errors are negligibly small.

At present a direct comparison between the Atomichron and the N.P.L. standard is in progress at Teddington in accordance with a recommendation made at the ninth meeting of the Union Radio Scientifique International.

Future Developments

Although it would be unwise to predict the accuracy that might ultimately be obtained with atomic standards, it is safe to predict from experience already obtained that they will revolutionize the measurement of time and frequency. The caesium standard depends on several very simple and fundamental processes: the evaporation of atoms from an oven; their deflection in a non-uniform magnetic field; the absorption and emission of r.f. energy; and the detection of atoms through ionization by a hot tungsten wire. The size and complexity of the equipment are governed on the one hand by the speed of the atoms, and on the other by the transformation of the frequency of resonance to a suitable low value. The beam chamber can be simplified if some means of slowing down the atoms without introducing adverse effects can be developed, and advances in valve design will simplify the frequency transformation. These problems have yet to be solved, and we are in the meantime building a long beam chamber at the N.P.L. which should give an accuracy within a few parts in 10^{11}.

The ammonia maser is also a potential standard, and various ingenious methods which are being investigated for changing the normal distribution of atoms and their energy levels may make the maser technique applicable to other molecules, and to atoms such as those of caesium. The maser seems bound to have important applications in radio, quite apart from that of frequency standardization.

The Unit of Time

As a result of all these developments, the physicist can now express his measurements in a unit of time interval which is a fundamental physical constant and is independent of astronomical measurements. If the precision of measurement exceeds 2 parts in 10^9, the atomic unit is the only one he can use without adding to his errors of measurement, and the provisional unit adopted at the N.P.L. has therefore been made available for immediate use.

Although the atomic unit is adequate for most purposes, it is not suitable for measurements extending over very long intervals because, although the unit can be integrated over periods of years by means of quartz clocks, and although it is usually possible to avoid uncertainty due to clock stoppages by correlating the readings of a number of clocks, it is possible that the

* Essen, L., Parry, J. V. L., and Pierce, J. A.: 'Comparison of caesium resonators by transatlantic radio transmission', *Nature*, 1957, **180**, p. 526

clocks used in a particular system might all stop and the time record thus be lost.

It is clear, therefore, that integration over long intervals must still be effected by astronomical measurements. One possibility would be to have two units of time, the atomic unit for physical measurements and the astronomical unit for civil purposes and astronomical measurements; but such a solution would inevitably lead to confusion, and it is preferable to link the two units together. For this purpose, comparisons are now in progress to determine the caesium frequency in terms of the second (of ephemeris time); and to the astronomical definition of the second given at the Dublin meeting of the International Astronomical Union the following note was added:

> After the frequency of an atomic frequency standard has been determined to sufficient accuracy with respect to the second of Resolution 1 the atomic standard may be used to make the second immediately available.

There is, however, as I have explained, no need to wait for the adoption of the final value before the atomic standard is used for physical measurements. It already provides a unit of time and frequency which is sufficiently precise for all applications that can be foreseen.

Discussion

The short discussion after the London lecture ranged, *inter alia*, over the frequency of caesium, the emission of the caesium atoms from the oven, difficulties arising from sidebands in the oscillators, and American attempts at slowing down the beam of atoms. The chairman, Mr. J. K. Webb, brought the meeting to a close with a brief speech of thanks to the author, in which he pointed out that the order of accuracy aimed at corresponded to a loss or gain of one second in 1000 years.

Acknowledgments

The work described on the atomic clocks and quartz standards at the National Physical Laboratory has been carried out by a team including Messrs. J. V. L. Parry, J. McA. Steele and E. G. Hope and has been or will be described in a number of publications. It has formed part of the research programme of the Laboratory and is published by permission of the Director.

Summary

The physical basis of the atomic clock is the frequency of the radiation absorbed or emitted when an atom or molecule changes from one energy state to another. The first operational clock at the National Physical Laboratory made use of a transition of the caesium atom which gives a frequency near 9·2 Gc/s. The experimental technique employed to detect the transitions is known as the atomic-beam magnetic-resonance method, which was developed for atomic research at Columbia University. The magnetic moments of the atoms suffer a reversal when transitions occur, and this enables the beam to be focused on to a detector. The technique avoids the various effects which normally broaden atomic resonances; in the N.P.L. model the resonance is only 300 c/s wide, and the setting to the peak can be made with a precision within ± 1 part in 10^{10}. With care in the design of the electronic circuits, the frequency can be related to that of the quartz working standards without significant loss of precision.

The quartz standards are used to monitor the frequency of the MSF standard-frequency transmissions, which thus in effect make the atomic standard available over a wide area. They have made it possible to compare the N.P.L. standard with a caesium standard, made in the U.S.A. and called the Atomichron, and to show that the two standards, of very different construction, agree to within 1 part in 10^9.

Another type of standard, developed in the United States and the Soviet Union, is based on a transition frequency of the ammonia molecule. In its modern form this is known as the maser; and though at present it should be regarded more as a stable oscillator than as a definitive standard, it has great potential importance.

It is safe to predict that atomic standards will revolutionize the measurement of time and frequency, although an astronomical unit is still required to preserve the continuity of time measurement over long periods.

NEW TRICKS FOR ACE

ACE, the latest digital computer to be built at the National Physical Laboratory, Teddington, has begun working. It is a considerable advance on its predecessor, the pilot-model Ace, in its increased operating speed and larger storage capacity.

It is a serial machine in which the numbers and instructions have 48 binary digits. The instruction specifies a three-address operation of the form: function $(A, B) \rightarrow C$, which can be performed at a maximum rate of 30000 per second. Mercury delay lines are used for the main working store and the rapid-access store, and four magnetic drums (rather than ferrite mesh) for the backing store.

Although its main use as a 'second-generation' computer will be in the development of new mathematical techniques, this very fast machine will be required for many other tasks, such as the design calculations for nuclear reactors and high-speed aircraft, and for general field problems concerned with the flow of fluids and the solution of partial differential equations. Ace enables the pressure distribution on the wing of an aircraft to be investigated thoroughly by means of a very fine three-dimensional mesh of 8000 points.

Input and output are currently on punched cards, allowing an input speed of 2000 binary digits per second; but magnetic tapes will be fitted later, as an extension to the store. The drum store, multiplier and divider—which contains facilities for 'floating point' arithmetic—are independent units, enabling parallel operations to be carried out.

ADVANCED REACTORS

3. Homogeneous Systems and Fuel Cycles

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Reactors with solid fuel elements were the theme of the first two parts of this article (October Journal, p. 541; November Journal, p. 590) which is based on a lecture to an Ordinary Meeting of The Institution on the 5th December 1957. In this final part, the author, who is now Assistant Director (Reactor Research Policy) at Harwell, considers homogeneous reactors, examines the influence of fuel cycles on advanced-reactor development, and offers some thoughts on small reactors for ships and other purposes.

J. V. DUNWORTH, C.B.E., M.A., PH.D.,
ASSOCIATE MEMBER

I HAVE discussed those reactors which have a solid bar or plate for the fuel element. The fuel is normally held in a gas-tight can so that fission products are confined to the fuel element itself. The result is an 'inactive circuit', containing no fission products. The opposite is true of homogeneous reactors, which can be based on water, molten metals, fused salts, organic liquids, and fluidization techniques. Only the first of these has progressed to the point where a major project exists anywhere in the world.

Homogeneous aqueous reactors

The homogeneous aqueous reactor (H.A.R.) uses water at not more than 270°C, corresponding to a pressure of about 100atm. The system has three main variants, which arise partly from the use of the reactor, partly from engineering considerations in design, and partly from the physics of the system and the chemical properties of the substances involved. The most complicated concept is one where there is a central core of fissile material in solution, surrounded by a separate annular compartment known as a blanket (Table 1).

The only acceptable core liquid is a solution of uranyl sulphate. The blanket contains a slurry of fertile material, being separated from the core by a neutron-transparent window. One cannot yet obtain an adequate density of fertile material in the blanket if it is in solution. The core and blanket liquids are circulated through separate

1 *In-pile section of a loop for insertion in the research reactor Bepo to study the CO_2/graphite reaction in the presence of radiation*

heat exchangers adjoining the reactor vessel. The two-zone arrangement has been pioneered at the Argonne Laboratory and should give the best neutron economy for a homogeneous reactor, since the bulk of the neutrons are born in the core and there is a maximum chance that they will be absorbed in fertile material in the blanket rather than be lost from the system to the shield or in parasitic capture.

A rather less attractive arrangement from the nuclear point of view is to have only one region in the reactor, containing both fissile and fertile material. Possible fuel concentrations in a one-zone H.A.R. are (per kilogramme of heavy water): 250g thorium oxide; 10g uranium dioxide. Engineering design is much simplified, and an organization in the United States is carrying out a detailed study of the concept. In particular, they are intensively studying the problems of maintenance of such an active circuit.

Table 1. Abbreviated specification of typical two-zone H.A.R.

Core fluid: 1g U233 as UO_2SO_4 dissolved in each kg of heavy water
Blanket fluid: 1kg ThO_2 as slurry per kilogramme of heavy water

	Core system	Blanket system	Entire system
Diameter, ft	7	11	—
Operating pressure, lb/in.²	1800	1800	—
Operating temperatures, °C	240°–290°	240°–290°	—
Mean flux in reactor zone, neutrons/cm²/s	10^{15}	5×10^{13}	—
Fluid circulating rate, g.p.m.	20000	6000	—
Mean power density in reactor zone, kW(heat)/l.	60	6	—
Thermal load, MW(heat)	300	100	400
Electrical output (net), MW	—	—	96
Material inventories (including processing), kg:			
U233 (including Pa233)	400	70	110
ThO_2	—	24000	24000
D_2O	17000	20000	37000

Laboratory studies have been undertaken in Britain, France, the Netherlands and the Soviet Union, and zero-energy reactors have been built. An experimental power reactor, HRE1, was operated briefly at Oak Ridge National Laboratory, U.S.A., some years ago. It had a thermal output of about 1 MW.

A second reactor system, HRE2, has been built at Oak Ridge with a separate core and blanket. After only a short time of working, the vessel separating the core and blanket developed a serious leak, and the system is now being operated as a one-zone reactor. Corrosion is one of the most crucial developmental problems, especially with the separate core and blanket system.

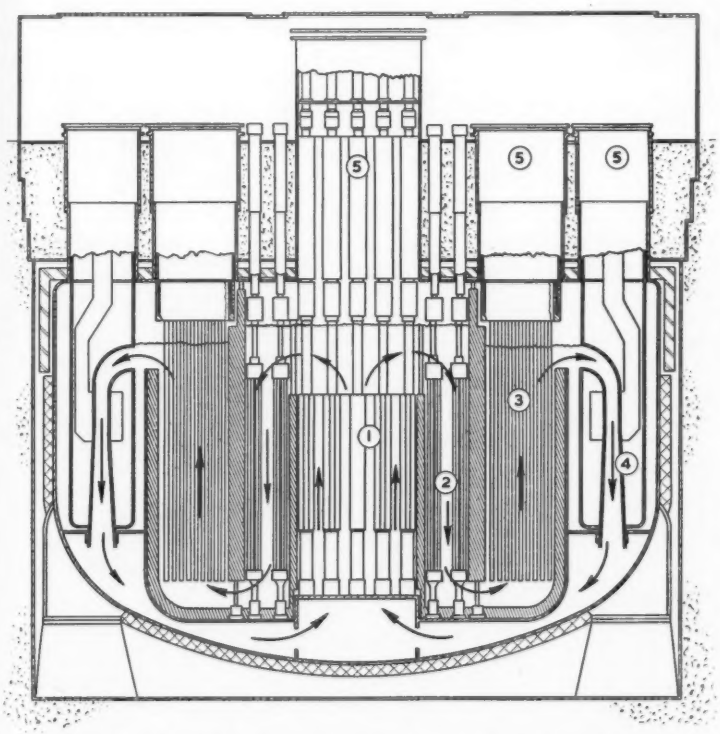
The better neutron economy of the latter arrangement will be achieved in practice only if a comparatively thin, non-neutron-absorbing partition between core and blanket can be developed which is reasonably corrosion-resistant and therefore has a long life in the reactor system. The problem of pressure-balancing between core and blanket may be solved by having a fairly large and direct connection between the two. This would, however, allow some leakage from core to blanket, and vice versa.

Processing the fuel-bearing liquids in a homogeneous reactor is not expected to present any serious technical problems.

Control of the reactor in normal operating conditions should be relatively simple, as the reaction is self-stabilizing because of the large temperature coefficients of expansion of the fuel-bearing liquids. Arrangements for inserting and removing fuel and for varying the density of fuel in the fuel-bearing liquids to give nuclear control will involve problems at least as complex as the control problems of a more conventional reactor.

A homogeneous reactor must be leak-tight to a very high degree and yet allow removal and replacement of highly active components such as pumps, valves and even heat exchangers. One scheme for doing this is to carry out the work under a pool of water by flooding the relevant reactor compartment. It must be possible to do the work quickly and reasonably cheaply and with a minimum demand on skilled staff, or maintenance costs may offset the lower over-all fuel costs which stem from the absence of fuel-fabrication charges.

The H.A.R. has reached the stage where a long and expensive process of detailed development is called for. There is a reasonable certainty of technical success, but not yet of economic success or low capital costs.



2 *Schematic of a 200 MW (heat) internally cooled liquid-metal-fuelled reactor*

1 Core: all-graphite fuel calandria
2 Blanket: graphite containers for fertile slurry
3 Graphite bayonet-tube heat exchangers
4 Electromagnetic circulating pumps for bismuth coolant
5 Removable shielding plugs

Liquid-metal-fuel reactors

Several proposals have been made during the last ten years for a liquid-metal equivalent of the H.A.R., but no reactor has been built so far. A reactor concept has been evolved, employing a core and blanket as in the H.A.R. so as to secure maximum neutron economy. It seems essential to use bismuth as coolant and fuel carrier if anything approaching a system self-maintaining in fissile material is desired. The core would be a solution of uranium in bismuth, while the blanket may be a slurry of the thorium–bismuth compound—Th_3Bi_5—in molten bismuth. Graphite would be the moderator, in contact with the core and blanket fuel fluids.

As with the H.A.R., there are severe problems of corrosion, maintenance and active circuits with this reactor, but another snag is that the fuel fluids are solid at room temperature. Its substantial advantage is that it obviates high-pressure circuits, while the high thermodynamic efficiency should help economically.

Studies of this reactor system are still at an early stage. Basic metallurgical data are known for the core solution, but few of the properties of blanket slurries have been examined. Some preliminary work has been carried out on core processing, but little work has been done on blanket processing. The effect of irradiation on

3 *Water tank used for shielding studies, placed against plane neutron beam emerging from Lido reactor*

techniques for corrosion inhibition is still largely unknown, and a major study of mass-transfer and corrosion problems is required. Much work remains to be done on the structure of the graphite moderator and on its behaviour in contact with bismuth metal and with solutions or slurries.

A long and expensive programme of research and development is needed, with no certainty of technical success or that the reactor concept can offer significant advantages over other schemes.

Some consideration has been given to employing a static liquid-metal fuel cooled separately by a liquid metal not containing fuel in solution or suspension. This is an 'internally cooled reactor'. The fuel elements may consist of a canned solution or suspension, but interconnected fuel spaces with a coolant passing through in separate tubes seem more likely.

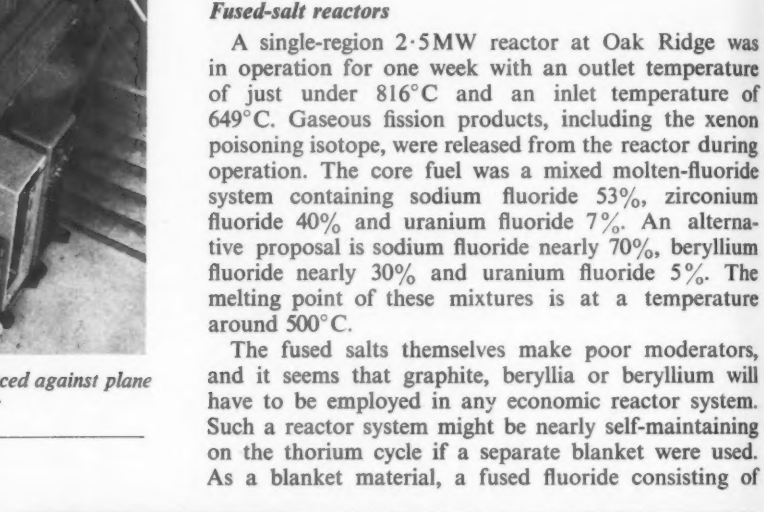
A small stream of fuel from the calandria would be circulated continually through a processing trap attached to the reactor for adjustment of the concentration of the fuel and for the removal of gaseous and other fission products. For example, many non-volatile fission products, including the rare earths, can be removed by extraction with a eutectic fused-salt mixture of sodium, potassium and magnesium chlorides.

One of the problems of a bismuth-liquid-metal-fuel reactor is the large amount of bismuth required. Several tons of bismuth have to be invested in a reactor for each megawatt of installed electrical capacity. If bismuth-liquid-metal-fuelled reactors alone were built in the United Kingdom, we would need very roughly 10000 tons of bismuth a year.

Fused-salt reactors

A single-region 2·5MW reactor at Oak Ridge was in operation for one week with an outlet temperature of just under 816°C and an inlet temperature of 649°C. Gaseous fission products, including the xenon poisoning isotope, were released from the reactor during operation. The core fuel was a mixed molten-fluoride system containing sodium fluoride 53%, zirconium fluoride 40% and uranium fluoride 7%. An alternative proposal is sodium fluoride nearly 70%, beryllium fluoride nearly 30% and uranium fluoride 5%. The melting point of these mixtures is at a temperature around 500°C.

The fused salts themselves make poor moderators, and it seems that graphite, beryllia or beryllium will have to be employed in any economic reactor system. Such a reactor system might be nearly self-maintaining on the thorium cycle if a separate blanket were used. As a blanket material, a fused fluoride consisting of



4 *Computers play a major part in reactor studies*
This is an analogue machine used for calculations on reactor kinetics

beryllium fluoride 16%, lithium fluoride 71% (made from the separated isotope lithium 7) and thorium fluoride 12%, has been suggested. The cheaper sodium fluoride could possibly replace lithium fluoride.

The reactor fuel would be contained in an Inconel circuit, while the beryllia moderator might be canned in a nickel–aluminium alloy.

Fuel cycles and advanced reactors

Apart from reactors which consume pure fissile materials and which do not themselves contain fertile material, all reactor systems produce fresh fissile material as they operate. If their fuel is natural or enriched uranium, plutonium is produced. There is no technical necessity to recover this plutonium by chemical processing of the fuel after its removal from the reactor.

Present diffusion plants for making uranium 235, however, are large and expensive, with a sizeable capital investment before any product is available. It is likely, therefore, that plutonium will be used for enriching nuclear reactors in the period when the more advanced reactors are coming into large-scale commercial use.

The development of an advanced gas-cooled reactor such as A.G.R. may lead to higher fuel costs than those of a natural-uranium reactor but should enable a more compact and highly rated system to be built and therefore reduce capital costs. If enrichment is carried to the limit and no fertile material whatsoever is introduced into a reactor, capital costs will almost certainly be at their lowest, provided that the cost of the fuel inventory is not too high.

One may discern a broad generalization, to which there will be significant exceptions. It is that reactors to supply base-load power will be designed to operate with a cheap fuel such as natural uranium, even if this means that the reactor has higher capital costs. Reactors to supply power on a lower load factor will tend to use the more expensive enriched fuel in order to secure lower capital costs. One of the more immediate purposes of developing advanced reactors may be to provide power at a lower load factor rather than to replace proven base-load designs.

Where a small low-capital-cost reactor is required, as in a ship, a fissile-material burner may be of considerable importance. Since it may be assumed that plutonium will be cheaper than uranium 235, one can expect that plutonium will be used for fuelling such a system, as has been stated recently by Sir John Cockcroft.

The only way to consume more than about 1% of the U238 in natural uranium is by means of the fast reactor, which theoretically can produce two atoms of plutonium for each one consumed. However, this significant gain is of no immediate economic importance, as the average life of a plutonium atom in a practical reactor and its associated processing plant is many years, and the decrement rate is of the same order as the interest rate for money. As a result, it is almost certain that a large part of the gain factor will be sacrificed to facilitate engineering design and to obtain lower over-all operating costs. What is significant about a fast reactor is that a practical design can exist whereby one can produce at least as much plutonium as one consumes and thus make it possible in the future to consume U238.

5 *View of an American reactor, suspended from towers for shielding studies in connection with nuclear-powered aircraft*

The reactor is stored in the pool beneath it

In a thermal reactor it is unlikely that an effective plutonium-reproduction factor in excess of 0·8 can be achieved. This has led to the curious misunderstanding that plutonium cannot be used satisfactorily in a thermal reactor.

In practice, up to about 75% of the plutonium 239 fed into a thermal reactor can be consumed, since the plutonium 240 poison, which is formed in the ratio of one atom to two fissions of Pu239, is converted into a fissile isotope, Pu241, by absorption of a second neutron. This fraction is at least as great as the fraction of U235 which can be consumed in a thermal reactor, since the poison U236, although formed in smaller quantities than Pu241 (one atom for four fissions of U235), does not give rise to a usable daughter when it absorbs a neutron to form U237.

The plutonium–uranium 238 fuel cycle is the basis of the fast breeder reactor. The thermal breeder reactor is based on the thorium–uranium 233 fuel cycle. To start off the latter cycle, either U235 in separated form or plutonium must be available. If plutonium is used, it

6 *The Russian atomic ice-breaker* Lenin, *shortly before her launching on the 5th December 1957 in Leningrad*
One of its two temporary sponsons is in the foreground

must be acceptable chemically to the breeder reactor as well as U233.

By contrast, U235 has the same chemical technology as U233, which forms the basic fissile fuel in a thorium breeder cycle. If a thorium breeder cycle is started off in a fully homogeneous reactor system with U235, the U236 poison grows and mixes with the U233 which is formed, and is separable from it only by isotopic separation processes.

The thorium breeder reactor is usually associated with homogeneous systems; in the foreseeable future, the aqueous project is the only homogeneous one which seems likely to be developed for commercial use on an appreciable scale. However, the thorium fuel cycle may also be used in the high-temperature gas-cooled reactor in its application to large land-based power stations.

The design of a natural-uranium reactor is conditioned by the need to go critical. This results in a fairly high moderator/fuel ratio to minimize resonance trap. This is not so if the reactor is used on the thorium fuel cycle. Maximum nuclear economy will be associated with a lower moderator/fuel ratio and therefore lower capital costs (excluding fuel inventory).

It is not generally realized that, technically, the thorium fuel cycle can be employed with the more conventional stage 1 and stage 2 reactors. For example, a Calder Hall reactor can operate on a thorium fuel cycle as a breeder system, producing as much U233 as it consumes. It is the high cost of the fuel inventory in such a low-rated reactor which at present prevents the use of this fuel cycle.

Reactors for small outputs and for ships

The development of nuclear power for large land-based stations can make the greatest contribution at present to the United Kingdom economy, since the savings in fuel imports by this method far exceed possible savings in any other direction.

There is nevertheless much interest in small reactor systems providing about 20 MW of electricity, suitable for employment in ships or for use on land in countries where they will not be connected to a national Grid. They must be simple and reliable, as expert assistance will not be available. Consequently, the more advanced reactors are unlikely to find these applications until after 1970.

Pressurized- and boiling-water reactors are acceptable for ships, as experience has been obtained already in the United States and is now being obtained in Russia. There is also the possibility of developing a scaled-down version of the gas-cooled graphite-moderated reactor to supply, at reasonable cost, power down to about 30 MW of electricity or its equivalent in shaft horse-power. Size and weight make it not so attractive for the smaller ship, though some form of the high-temperature gas-cooled concept may assist in this direction. Small reactors cannot go critical with natural-uranium fuel because of the large neutron-leakage; they depend, therefore, on a supply of cheap fissile material.

The suggestion has been made that, of the more advanced reactors, an H.A.R. could be designed to be extremely reliable for small power outputs, and a prototype may be operating in a few years' time in the United States. A United Kingdom study has been based on this concept, using plutonium as fuel in a one-core solution system with a 4ft-diameter tank containing about $2\frac{1}{2}$ tons of water. No attempt would be made to process the core fluid, but adjustment of the fuel content would be needed every few years.

The organic-liquid reactor

The main application of the organic-liquid concept appears to be in low-power units. It uses a mixture of diphenyl and the three terphenyl isomers as both moderator and coolant. In effect, the water in a pressurized-water reactor is replaced by the organic liquid. Such liquids are reasonably resistant to irradiation damage and can have a life of several weeks in an operating reactor. Furthermore, the irradiation damage produces new substances which remain liquid and are miscible with the original liquid. Heat-transfer properties of the organic liquid are not seriously affected by the presence of appreciable quantities of decomposition product, one authority stating that as much as 40% can be tolerated.

No precise data are available on the cost of replacing the organic liquid, but it is not expected to be much

7 *The U.S. Submarine* Nautilus

greater than 0·1d. per kWh generated. Future development will reduce this figure. From a reactor providing about 20 MW for use on land or in a medium-sized cargo ship or cargo liner, about 100 gal of organic liquid would have to be disposed of each day. The liquid is not radioactive.

Organic liquids obviate the high pressures inherent in a pressurized-water system, but they have very much poorer heat-transfer characteristics and may be less resilient to momentary overload or to regions in the reactor operating at above-average temperature. The fact that organic liquids do not get radioactive may make it possible to operate the coolant circuit unshielded.

Organic liquids do not appear to cause any serious corrosion problems. If the canning should fail, the liquids will not corrode the fuel element at all quickly. There will be ample time to take appropriate measures before the cooling circuit becomes highly radioactive with fission products.

The United Kingdom Atomic Energy Authority have been making irradiation studies on organic liquids for some years. A small reactor experiment in the United States has been operating most satisfactorily for some months (Table 2). In this, the fuel element is similar to that developed for the pressurized-water 'army package' power reactor and uses uranium oxide dispersed in steel.

Table 2. Organic-moderated reactor experiment

Composition of moderator and coolant (not irradiated)	
Diphenyl 16%	
Orthoterphenyl .. 46%	
Metaterphenyl .. 32%	
Paraterphenyl .. 6%	
Vapour pressure at 316°C (600°F) ..	1·2 atm
Density at 316°C (600°F)	0·86 g/ml
Specific heat	0·55 B.Th.U./lb/°F
Thermal conductivity	0·66 B.Th.U./ft/h/°F
Coolant is a thick slurry at 21°C (70°F)	
Coolant is completely liquid at 93°C (200°F)	
Maximum fuel-element surface temperature	427°C (800°F)
Maximum coolant velocity	15 ft/s
Bulk-coolant temperature	<371°C (700°F)
Reactor power	10 MW (heat)

A further variant is an organic-liquid coolant with a separate moderator of some other material, e.g. heavy water. The cost of replacing the organic liquid after irradiation breakdown will be less than that where the organic liquid is used also as a moderator.

Summary

It is unrealistic to think that more than a small number of reactor systems will be developed for large-scale use in the next 20 years. Future land-based systems will have to do more than be roughly competitive with an existing nuclear power station. The new system will have to be known to work reliably and to have a definite advantage before it will be accepted for commercial power generation in this country.

The time scale for achieving significant commercial operation with any given reactor concept exceeds ten years and will approach 20 years for the more intricate systems. Research and development on almost all advanced reactors involve complex engineering, physical and design work on such matters as fuel cycles, neutron economy, kinetics and safety. Equally complicated are the material and compatibility problems. These investigations have to proceed before, during and, in the present state of knowledge, after the main mechanical-engineering design phase.

It is by no means self-evident that base-load power stations will end their life as peak-load stations, since their fuel-operating costs are low. One line of advanced-reactor development may well be to provide stations which are optimized for low load-factor operation at all stages of their life.

The evolution of an advanced-reactor system will be conditioned by the fuel cycle on which it is to operate. Fuel from one reactor may be used for another reactor with a different design and purpose. In particular, small power stations with an electrical output of about 20 MW, and ship reactors, may use plutonium from base-load stations.

The Four Pillars of The Institution

3 THE MEASUREMENT AND CONTROL SECTION

DESPITE Lord Kelvin's dictum, 'When you can measure what you are speaking about and express it in numbers, you know something about it', it was 57 years before The Institution found it desirable to form a separate Section for the 'reading and discussion of papers on meters, instruments and cognate subjects'. Perhaps this is not surprising, since all Sections of The Institution are concerned with measurement to some degree; and, if the Supply Section can be likened to the muscles which produce physical energy, the Measurement and Control Section provides the sense organs and nervous system which permeate the whole body.

Although 30 years old, the Section is still, as is appropriate for The Institution's nervous system, the smallest, with a membership of hardly more than 3000. It is particularly active in co-operation with the three other Sections, with which it frequently combines for joint meetings and conventions. During the past ten years, out of a total of 121 meetings, no less than 36 have been joint meetings with one of the other Sections.

Father of electrical measurement

Long before the formation in 1928 of the Meter and Instrument Section, as the Section was then called, The Institution gave much of its time to the principles of electrical measurement and the design of measuring instruments. Such well known names as W. E. Ayrton, A. C. Campbell, Sir William Crookes, C. V. Drysdale, W. Duddell, S. Evershed, J. A. Ewing, R. T. Glazebrook and C. G. Lamb frequently appear in the issues of the *Journal* published around the turn of the century; and Lord Kelvin, who may be considered the father of electrical measurement, became President of The Institution in 1874 and again in 1889 and 1907.

On the 7th December 1928, following successful negotiations with the Meter Engineers Technical Association, the inaugural meeting of the Meter and Instrument Section was held and was presided over, appropriately enough, by the then President, Lt.-Col. K. Edgcumbe (later the Earl of Mount Edgcumbe) who, like his famous predecessor Lord Kelvin, had himself founded an instrument-making firm. In this and the following sessions, papers were read at approximately monthly intervals covering a wide range of topics, including several on instrument transformers and on the precise measurement of alternating current.

It was suggested in 1931 that a title such as 'Electrical Measurement and Instrument Section' would be more descriptive of the Section's activities; but it was not until 1941 that the simpler and more comprehensive name 'Measurements Section' was adopted. In 1934, when the Supply Section was formed, the General Purposes Committee of the Council wished to make the rules of the specialized Sections, which now numbered three, more uniform, and as a result the scope of the Section was defined for the first time.

Interlocking interests

It was laid down that 'the Section shall include within its scope all matters relating to the study, design, manufacture or use of instruments, meters or protective devices used in electrical engineering', but it was soon found that many members of The Institution interpreted this in too narrow a fashion and believed that the Section dealt exclusively with integrating meters and instruments rather than with all aspects of electrical measurement.

It was for this reason that in 1941 the name of the Section was changed and the scope redefined as 'all matters relating to measurement and control, the design and application of the apparatus and the materials employed in connection therewith'. It is significant that the study of materials was now added to the scope of the Section, and this still further increased the extent to which the Section's interests were interlocked with those of the other Sections, which were all interested in the properties of the materials they used and in the development of new and better ones.

The Second World War saw widespread development in the field of servomechanisms and automatic control, which was followed by the rapid evolution of electronic computers. Both these developments attracted the attention of the Section, and it was agreed by the Council that these fields of activity were appropriate to the Section.

How the scope widened further

The Section organized a most successful Convention on Automatic Regulators and Servomechanisms in May 1947, at which most of the developments of the war years were reported, the papers being published in special issues of the *Proceedings*, as for the earlier Radiolocation Convention organized by the Radio Section. Following this convention, the scope of the

Section was further widened in 1948 to cover 'all matters relating to measurement and to process and position control, using electric and magnetic means'.

In order to clarify the fields covered by this statement, it has been laid down that 'the aspects covered include the study, design, manufacture, construction, installation, operation, application, employment and maintenance of the devices used in connection with electric and magnetic measurement and control, and the study of the materials employed therein', and 'the applications covered include the measurement of all electric, magnetic and dielectric functions and of other entities by electric and magnetic means, telemetering, network analysers, computing devices, industrial and other forms of process and position control including servomechanisms'.

The Radio link

Thus it is seen that the area covered by the Measurements Section was widened to include not only all forms of process and position control but also telemetering, network analysis and computing devices as being essential parts of the broad field of measurement. So a close link was formed between the Radio and the Measurement Sections which has become continually stronger during the past ten years.

Not only have many of the Measurements Section meetings been held jointly with the Radio Section, but also two conventions, on Digital-Computer Techniques and on Ferrites in 1956, have been organized in collaboration with that Section. The close relationship between the two Sections is seen also in the *Proceedings* (Part B) which, since the reorganization of 1955, now includes, besides the papers of the Radio and Telecommunication Section, most of those of the Measurement and Control Section, as it has been called since 1955.

It is not only in the technical field that co-operation between the two essentially light-current Sections has flourished: for several years now a joint dinner-dance has been arranged in the early spring, and this has always been a well attended and extremely friendly function.

Symposia and conferences

The wisdom of widening the scope of the Measurements Section in 1948 is exemplified by the subjects of the symposia and conferences which have been held almost at yearly intervals since that date: in 1949 on Ferromagnetic Materials, in 1950 on Radiation Monitoring Apparatus, in 1951 on Electrical Meteorological Instruments and on Electrical Instrument Design, in 1953 on Insulating Materials, and in 1956 (as mentioned above) on Digital-Computer Techniques and on Ferrites. Another convention, planned for February 1959, is to take the form of a series of specialist discussion meetings on new digital-computer techniques.

The Measurement and Control Section has always had close links with industry and with Government departments; but it is natural that the closest bond should be with the National Physical Laboratory, which has furnished not only many papers for publication and for discussion at meetings of the Section but also several of its Chairmen. This is not surprising, as for many years it has been customary for the Section Committee to invite the Director of the N.P.L. to send a representative to its meetings, who frequently, after serving for one year as a non-voting member, has been elected to serve in his personal capacity.

In the field of automation, the Section has played an important part, not least in providing a focus around which the British Conference on Automation and Computation has grown.

The number of British physicists and engineers working directly in the field of measurement and control has not until recently been large, and so it is not strange that the Measurement and Control Section is much the smallest of the four. But it has always been an active Section, and it has, by its close links with the others, influenced the whole.

Thus, standing amidst those three other more massive pillars of that imposing edifice, The Institution, the Measurement and Control Section may be likened, in its delicate motivation, to a slender and cunningly constructed column, throwing out at its capital height the intricately designed fan tracery which unites and completes the statement of the building.

American Engineering Headquarters

UNITED Engineering Trustees Incorporated, the board of which is composed of three representatives from each of the five professional societies in the United States representing the major branches of engineering—mechanical, civil, electrical, mining and chemical—have announced the election of Mr. Andrew Fletcher as president in succession to Mr. Walter J. Barrett. Among other activities, United Engineering Trustees direct the research programmes of the Engineering Foundation and act in a fiduciary capacity for many joint activities of the engineering societies named.

The Corporation have purchased a site opposite the United Nations building in New York for the construction of a 20-storey United Engineering Centre. The present home of U.E.T. in West 39th Street will be sold, and the Engineering Societies Library will move into the new Centre. The five societies of U.E.T. have extended invitations to other American engineering societies to unite with them in using the new Centre as their headquarters.

It is expected that building will start in 1959, on the completion of a fund-raising campaign in which £1 785 714 will be obtained from commerce and industry and £1 071 428 from the 200 000 individuals who constitute the Engineering Societies' membership.

Wiring Regulations—Recent Interpretations

(Issued on the 1st December 1958)

THE 13th Edition of the Regulations for the Electrical Equipment of Buildings was issued on the 1st September 1955. The following abstracts of interpretations, the sixth group to be published,* are of general interest and involve clear-cut issues. As is customary, the names of inquirers are not included. In some instances the inquiries and replies have been edited to make the interpretations of more general application. In view of the interest widely expressed, arrangements have been made to release further abstracts of this kind at intervals depending on the number of inquiries of general interest received, but not more frequently than once in three months.

It has been suggested that it would be a convenience to users of the Regulations if Interpretations Abstracts could be collected together and issued in the form of a companion volume to the Regulations, perhaps divided into sections in the same way as are the Regulations. Users who would find such a volume helpful are requested to inform the Secretary of The Institution in order that the likely demand may be assessed.

It should be borne in mind that The Institution cannot undertake to comment on particular installations or types of equipment and material. Such a duty falls within the province of a professional consulting engineer or a testing establishment. Nor does The Institution attempt to adjudicate on differences of opinion which may arise between supply undertakings and consumers: the statutory provisions for dealing with such matters in Great Britain are contained in the Electricity Supply Regulations, 1937† (H.M. Stationery Office), and in Northern Ireland in the Regulations of the Ministry of Commerce.

Inquiry 46 *Regulation* **114(B)**

Is it permissible to feed a transformer for supplying an electric-bell circuit from a fused spur-box on a ring circuit?

Reply

An electric bell with its associated transformer may be regarded as a fixed appliance (see definition on p. 7 of the Regulations) and may thus be connected to a ring circuit in accordance with the appropriate requirements of Regulation 114(B)(i).

* Reprints of the following earlier sets of abstracts remain available, price 6d. each, post free:

	Interpretations	*Date of Issue*	*Reference, Journal I.E.E.*	*Regulations Nos.*
1.	1–22	3.9.56	1956, 2, Oct., p. 598	108, 112(B), 114(B), 115, 203, 204(B), 206(A), 207(G), 209(F), 229(B), 307(A), 314, 315, 316, 401, 403, 404, 405(B), 603(A), Section 8 Tables: C, 1, 7, 16–22
2.	23–27	3.12.56	1957, 3, Jan., p. 31	114(B)(ii), 214(B), 322, 403, 404 405(D)
3.	28–31	1.3.57	1957, 3, Mar., p. 154	407(iv), 503 Tables: 12–24, 26
4.	32–41	2.9.57	1957, 3, Sep., p. 496	General, 110, 115, 208(D), 218, 229, 311, 314, 315, 404, 405(C), 606(i)
5.	42–45	9.6.58	1958, 4, June, p. 305	101, 102, 104, 105, 114(B) Tables A and 2

† By virtue of Section 60 of the Electricity Act, 1947, and Section 1 of the Electricity Re-organization (Scotland) Act, 1954, these Regulations made by the Electricity Commission now have effect as if made by the Minister of Power and the Secretary of State for Scotland acting jointly under these Acts

Inquiry 47 *Regulation* **209(E)**

May a p.v.c.-insulated cable without a sheath be installed out of doors without further protection against direct sunlight?

Reply

For consumers' low-voltage wiring, the use of p.v.c.-insulated, non-sheathed cables is recognized only for installation on cleats or in conduit (see Regulations 209(F), 216 and 218). The use of non-sheathed cables is not recognized for wiring between consumers' buildings [see Regulation 229(B)].

The Regulations do not preclude the installation of p.v.c.-insulated, non-sheathed cables on cleats on the exterior surface of a building, provided that the requirements of Regulations 209(A), 209(F) and 216 are met, and no objection has been raised to their use where exposed to direct sunlight.

Outdoor use of p.v.c.-insulated or p.v.c.-sheathed cables is implied in B.S. 2004 'P.V.C.-insulated cables and flexible cords' and in B.S. 2746 'P.V.C. insulation and sheath of electric cables'. The latter Standard (note to Clause 4) states: 'To provide the best weather-resisting properties, it is recommended that the insulation of unsheathed cables for outdoor use should be black.' Regard must be had to Regulation 206 and Table 7 for the colour identification of conductors, which may, where desired, be effected by the use of coloured sleeves or discs.

Inquiry 48 *Regulation* **301(B)**

Where the cables of a 3-phase circuit are installed in trunking and are brought out of the trunking at a common point for connection to three physically separate items of single-phase switchgear, is it necessary for the single-phase switchgear to be rated for medium voltage? It is thought that the Note to Regulation 301(B) may be intended to apply only to fusegear which protects a number of low-voltage circuits connected to separate phases and installed in a common conduit or trunking, and not to fusegear connected between a 3-phase circuit in trunking and a number of physically and electrically separate low-voltage circuits.

Reply

For compliance with Regulation 301(B), fuses or circuit-breakers used to protect single-phase or 3-phase circuits installed in a common conduit or trunking must normally be rated for a voltage not less than the maximum r.m.s. voltage difference which may be present between the cables.

Fuses or circuit-breakers protecting individual low-voltage circuits and fed from cables run in such a common trunking need not be rated for a voltage more than that in the low-voltage circuits concerned, provided that the requirements of Regulation 109 are fully observed; in normal circumstances this will mean that the fuses or circuit-breakers

must be enclosed in earthed metal or incombustible insulating material, and unless units connected to separate phases are 6ft or more apart, means of access must be marked to indicate the maximum voltage present. If, however, any of the outgoing wiring from the single-phase fusegear is housed in the same enclosure as wiring connected to a different phase, the single-phase fusegear concerned must be rated for the maximum voltage difference between phases.

Inquiry 49 *Regulations* **406, 507** *and* **508**

Regulation 406 requires that the impedance of the earth loop be low enough to permit a current of three times the rating of the control fuse, and Regulation 507 indicates how tests for compliance with this requirement shall be carried out.

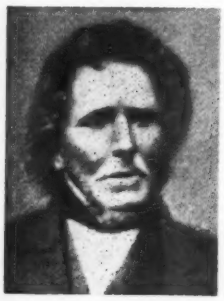
Regulation 508 appears to require that the resistance of an earth-continuity conductor shall not exceed 1 ohm if measured by a substantial alternating current, or ½ ohm if measured by direct current and if the earth-continuity conductor is not made of copper or copper alloy.

Is it necessary that both Regulations be complied with simultaneously? The opening words of Regulation 508: 'When a separate test', can be taken to mean that there is no need to test the earth-continuity conductors on every occasion.

Reply

Regulation 507 requires that each completed installation, and if possible each final sub-circuit, be tested by means of an earth-fault-loop impedance tester. If each final sub-circuit is so tested and the requirements of Regulation 406 are found to be satisfied, it is not normally necessary for a separate test of earth-continuity conductors to be made. This Regulation is intended to ascertain the impedance of the whole circuit involved in an earth fault, including that of the consumer's earth-continuity conductors, the consumer's connection to earth, the substation connection to earth, and the impedance of the transformer, and can only be applied after the installation has been connected to the supply.

It may be convenient, as for example during the process of installing the consumer's wiring or at some later date, to make a test of the integrity of the earth-continuity conductors of that installation. In such a case, it should be tested by the methods set out in Regulation 508. This Regulation states that 'It is normally satisfactory if... the ratio voltage/current, less the resistance of the return conductor, does not exceed 1 ohm.' It is thus not an absolute requirement of the Regulation that a reading of 1 ohm or less be always obtained; none the less, if the reading is found to exceed this value, it may be desirable to make further tests of the integrity of the earth-continuity conductors.



FORERUNNER IN WIRELESS TELEGRAPHY

621.396 : 621.392

James Bowman Lindsay (1799–1862), natural philosopher, was hailed by Marconi as 'the first man who thoroughly believed in the possibility and utility of long-distance wireless telegraphy'. The results are given in this article of an inquiry into the importance and value of Lindsay's work. Less than six months after submitting the article, Mr. Garner died, in September 1958.

the late R. H. GARNER, M.SC.TECH., MEMBER

When Thomas Carlyle in 1840 assembled his gallery of heroes, he found no place there for the man of science. Yet we today would put the best of such men high in the ranks of the intellectual nobility and would find it easy to cite examples of proud distinction, present and past. Also, as in other fields of human endeavour, we would recognize that there have been many brilliant workers who, although cast most truly in the heroic mould, somehow failed to attain the status which was their birthright and which they would certainly have reached in circumstances more favourable than those in which they lived.

Of such was James Bowman Lindsay, compatriot and contemporary of Carlyle himself: a natural philosopher who made notable contributions to science and learning and pointed the way to much that we now accept as an ordinary essential of our daily life.

Lindsay's researches in applied electricity, in particular, showed a remarkably acute perception of the course which fruitful future roads of development would follow. By reason of these, he can be classed as a pioneer of wireless telegraphy; and in this sense his work was given local prominence a year or two ago, regarding certain experiments carried out in the Portsmouth area.

That the experiments were actually performed is fully authenticated. They were reported in the *Hampshire Telegraph* on the 26th August 1854 and in the *Morning Post* two days later. They were also noticed in *Chambers's Journal* for September of the same year.

There is no reference to James Bowman Lindsay in the *Encyclopaedia Britannica* or *Chambers's Encyclopaedia*; and a scrutiny of the books on radio produced only one reference: on p. 2 of the 1913 edition of the wireless textbook by the late J. Erskine-Murray. However, a biography by A. H. Millar* and a section of Blake's 'History of radio telegraphy and telephony'† supply sufficient evidence to establish Lindsay's claim to an honourable place among the wireless pioneers.

* 'James Bowman Lindsay and other pioneers of invention' (Dundee: Malcolm McLeod, 1925)
† London: Chapman and Hall, 1928

A hermit's life

Lindsay was born at Carmyllie on the 8th September 1799 and died at Dundee on the 29th June 1862. In his early days he worked as a handloom weaver and in due course became a student at St. Andrews University, working at his trade during the college vacations. While at the University he studied arts and divinity, as well as science and mathematics; and with the educational equipment thus acquired he was able to make something of a living by teaching, when he turned to pursue his course alone in the world.

Alone he certainly remained, for he never married; and he lived the life of a hermit to the end of his days. We may suppose he took such employment as allowed him leisure for study and research, accepting the concomitant poverty as a hard condition of the freedom to inquire and learn.

It is sure that he was a lecturer in mathematics at the Watt Institution in Dundee in 1829, but in 1841 he was glad to accept an appointment as teacher in Dundee Prison at a salary of £50 a year. He was, nevertheless, gradually becoming known as a scholar of importance, and his merit was finally rewarded by the grant of a civil pension of £100 per annum in 1858, four years before his death.

There was in Lindsay the confidence of the profound thinker. There was also something of the madness we associate with genius: a blindness to the practical limits of a particular quest for knowledge. And it is interesting to notice that, while Lindsay's scientific inspirations were sound, his main literary labour was a philological task clearly beyond the individual effort of any single mortal man—nothing less, in fact, than the compilation of a gigantic multilingual dictionary.

The main line of his work, as seen in retrospect, was clearly in the application of physical science, and here his touch was certain and his vision clear.

Brilliant illumination

His earliest experiments of note appear to have been associated with electric lighting, as witness the prophetic words he wrote in the *Dundee Advertiser** of the 30th October 1835:

Brilliant illumination will be obtained by a light incapable of combustion; and on its introduction to spinning mills, conflagration there will be unheard of. Its beauty will recommend it to the fashionable; and the producing apparatus, framed, may stand side by side with the piano in the drawing room. . . . Being capable of surpassing all lights in splendour, it will be used in lighthouses and for telegraphs. The present generation may yet have it burning in their houses and enlightening their streets. . . . Electricity, moreover, is destined for mightier feats than even universal illumination.

There followed suggestions for welding by electricity and later, in the 1840's, a proposal for a submarine telegraph cable across the Atlantic. The next venture was in what can fairly be called experiments in wireless telegraphy or, to quote the inventor's own words, 'through and across water without submerged wires'.

The best of these experiments were carried out across the Tay at Glencarse in 1843, but there was a repetition in which he transmitted messages across the Mill-Dam, Portsmouth, where it was about 500 yards wide. This was in August 1854, as already mentioned, and resulted in a patent being granted for the Lindsay system.

The system was elaborately described for patent purposes by Lindsay himself, but it is easily condensed for modern readers into a few simple statements. The circuit consisted of a battery and some sort of keying device on one side of the river, connected to two electrodes in the water, the electrodes being spaced at a distance greater than the width of the river. A corresponding pair of electrodes on the other side were connected to a galvanometer via another battery.

On keying the circuit and obtaining a response on the galvanometer, it was clear that a telegraphic device had been produced, without the use of wires, which in this sense pointed the way to ultimate progress in underwater a.c. signalling and other forms of 'wireless' telegraphy.

An unfinished task

Outside his scientific researches, Lindsay was obsessed by his grandiose enterprise for a dictionary in 50 languages: his 'Pentecontaglossal Dictionary'. As a first measure, a foretaste of the possibilities of his dictionary, he drafted and published a 'Pentecontaglossal Paternoster'—the Lord's Prayer in 50 languages.

Of course, the dictionary itself was never finished—how could it have been? But he stuck to it doggedly to the end; and when he died, in his two-room lodging crammed with books from floor to ceiling, the bulky manuscript was found on the table, neatly written and methodically spaced to allow for further progress.

Of his other scientific work, one may mention the publication in 1858 of his book 'Chrono-astrolabe: a full set of astronomical tables'.

Dundee, where Lindsay spent practically the whole of his working life, has honoured his memory by a monument which bears this inscription:

A pioneer in electrical science; foretold the application of electricity as an illuminant, a motive power, to replace steam and a substitute for coal in heating. He devised an electric telegraph, 1832; suggested welding by electricity and produced a continuous electric light, 1835; proposed a submarine transatlantic telegraph, 1843; and accomplished wireless telegraphy through water, 1853. As a philologist his attainments were extraordinary. In 1828 he began the compilation of a Dictionary in 50 languages, uncompleted when he died.

An accomplished scientist; a profound student; an earnest Christian.

* An advertisement by Lindsay in the *Dundee Advertiser* of the 11th April 1834 is quoted in 'History of electrical engineering—3', by C. MacKechnie Jarvis, published in the *Journal* for May 1955 (p. 280)—Editor

A Review of the Proceedings, Parts A and B

Control Equipment for the British Grid

A short review of two Supply Section papers (Nos. 2626 and 2627) entitled 'Standardization of Control Facilities for the British Grid: Communications, Indications and Telemetering', by P. F. Gunning, and 'The Development of Communication, Indication and Telemetering Equipment for the British Grid', by G. A. Burns, F. Fletcher, M.B.E., C. H. Chambers, Associate, and P. F. Gunning. The papers were published in May 1958 and are republished this month in Part A of the Proceedings. Mr. Gunning is with the Central Electricity Generating Board, Mr. Burns with the Automatic Telephone and Electric Co., Mr. Fletcher with the General Electric Co., and Mr. Chambers was formerly with Standard Telephones and Cables Ltd.

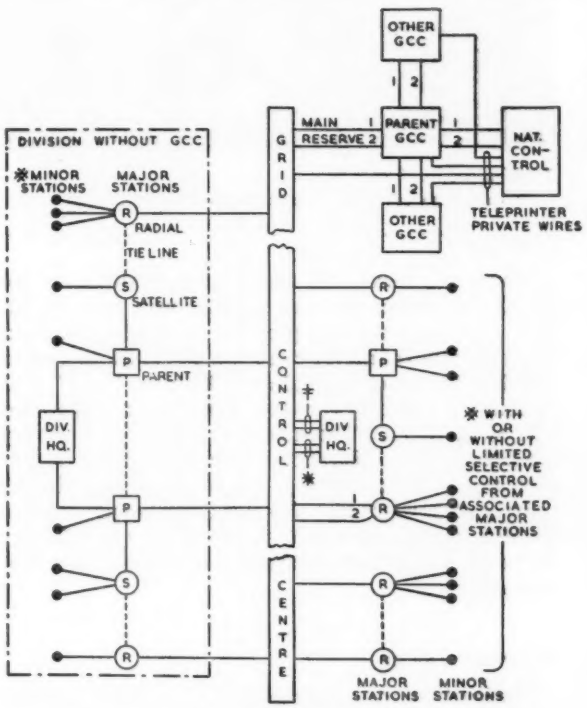
THE STANDARDIZATION OF EQUIPMENT FOR THE CONTROL of the British Grid was decided on by the British Electricity Authority in 1949, when it had become necessary after 15 years to re-equip the Grid control centres (G.C.C.). These centres had been separately equipped, in the early nineteen-thirties, with different systems of indicating, telemetering and telephone equipment. Although these systems had served their purpose, they could not provide facilities which operating experience over the years had shown to be necessary, nor, without expensive extensions, could they cater for the continual extensions of the Grid. As the G.C.C.'s were congested, it was decided to build new ones and, with recollections in mind of Grid control in wartime, to site them in more-suitable districts.

Telephone manufacturers who had supplied the earlier equipment were asked to co-operate with the Authority in the design of a 'standardized system', as it came to be called. A Telecommunication Technical Committee was set up, and the Authority specified the facilities to be provided. Because of the complex variety of stations and network conditions in the various control areas, the committee found that the standardized system could not be a precise installation with universal application. Instead, many items of basic equipment were standardized for installation in combinations to suit the requirements of any station or G.C.C. When the standard items had been developed and the parameters of the new system determined, the Authority was able to plan the new Grid-control networks and to issue the individual contract specifications for eight G.C.C.'s and 300 or more generating and/or Grid transmission stations.

Rented Post Office circuits are still, after 25 years of experience, the only practical means available of meeting the requirements of the Grid-control networks, mainly because of the complex Grid system, continual changes to transmission systems and the large number of stations involved.

General Network

The stations in a control area are planned either as major stations (of which there are three types—radial, satellite and parent) or minor stations (Fig. 1). Usually,



1 *Typical communication network for a Grid control area*

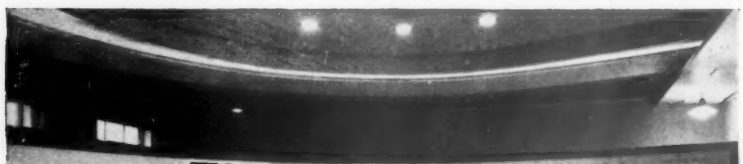
Transmission loss (including G.C.C. and station equipment) not to exceed 20 dB between G.C.C. and major stations, or 25 dB to major stations over tie-lines or to minor stations over direct routes

* Inter-P.A.X. junctions

‡ Low-loss junctions for automatie communication with stations in Division

a major station is a generating station or large attended Grid station, and a minor station a small Grid station or Area Board bulk-supply point. Minor stations send signals to and receive signals from a nearby major station. A major one sends signals to and from the G.C.C. and has a direct line to each of its minor stations, not usually more than three or four. A radial major station has a direct line to the G.C.C. To economize in rented lines,

the more distant major stations can be connected in groups of usually two, but up to four, stations. Either the most important station in the group or that nearest to the G.C.C. is made the parent station, with a direct line to the G.C.C. and to each of the associated 'satellite' stations.



2 *Thames South control room*
General view of loading desk and feeder flow diagram

Alternative means of communication between the G.C.C. and major stations, together with their dependent minor stations, are provided by tie-lines between major stations connected by separate Post Office lines to the G.C.C. In each control area the main 275kV Grid stations are served by two direct but alternatively routed lines to the G.C.C. The reserve line, which is normally available for administration traffic, is switched to take over service in the event of failure of the first line. A new network, which will also give direct-communication facilities between G.C.C.'s, is being provided for the national control centre, which since 1938 has co-ordinated operations.

Equipment Layout

The layout of equipment in each of the G.C.C. systems is different. Fig. 2 shows the Thames South control room, with its loading-control desk and diagrams.

Mosaic switching diagrams, comprising many thousands of small interchangeable plastic squares engraved to represent different items of transmission and switchgear equipment, have proved to be the only practicable means whereby Grid-control switching diagrams can keep pace with system expansion. The circuit-breaker semaphore symbols flash until corrected when they are in discrepancy with the automatic indicating signals from the stations.

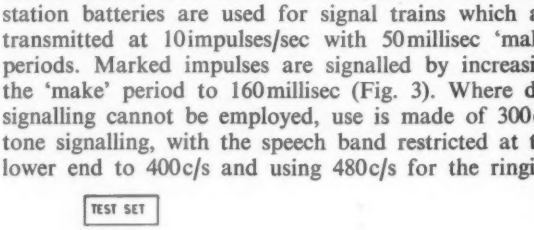
On the feeder flow diagrams, telemeters positioned in the mimic lines indicate the magnitudes and directions of active and reactive power in the corresponding Grid lines. In each line, a red lamp flashes when the current in the corresponding Grid line exceeds a pre-set value, and green lamps at the line ends light when the terminal Grid switchgear is opened.

The control desks are equipped with telephone keyboards from which it is possible to call or answer any station telephone in the area; control traffic has priority over administration traffic originating from the G.C.C., the associated Divisional headquarters or the stations. On the loading desk, recorders indicate the area net-transfer, total area generation and system frequency; also on the loading desk are 16-way visual telegraph and 100-point generation instructors for the stations in the area, and an indication of the rate of change of system frequency. An indication of daylight intensity is telemetered from one of the stations in the area.

During mains failure, Diesel-driven alternators serve the G.C.C., and the system-frequency instruments are automatically switched to an amplified signal from a selected Grid station.

As well as providing for general indications, telemetering and telephony, the standardized system enables unattended minor stations to be remotely controlled by power-station control engineers at the associated major stations. To cover failure of the rented line, this method of control is reinforced by automatic reclosure of the Grid circuit-breakers at the minor stations.

Most lines in the control networks are short enough for simplex earth-return d.c. phantom signalling. This method is reliable and inexpensive and does not interfere with speech or voice-frequency telemetering. At stations where the difference of earth potential in maximum fault conditions is less than 430 volts, the earthed 50-volt station batteries are used for signal trains which are transmitted at 10impulses/sec with 50millisec 'make' periods. Marked impulses are signalled by increasing the 'make' period to 160millisec (Fig. 3). Where d.c. signalling cannot be employed, use is made of 300c/s tone signalling, with the speech band restricted at the lower end to 400c/s and using 480c/s for the ringing



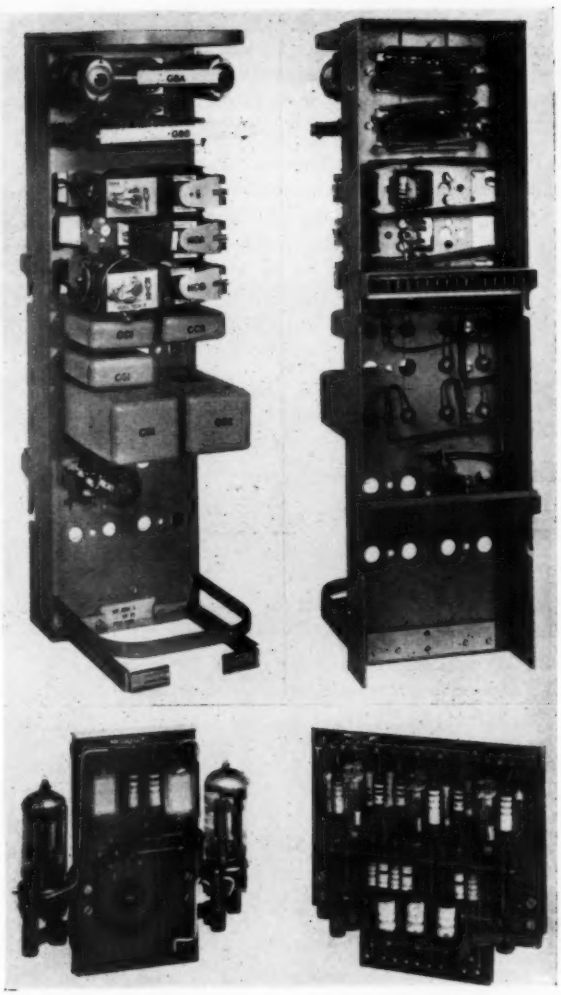
3 *Telephony and line signalling at outstations*
* Provided only at stations where rise of earth potential can exceed 430 volts r.m.s.

and 'busy' tones. The speech band is restricted at the upper end to 2000 c/s to permit the simultaneous transmission of speech and telemetering (at 2220 and 2340 c/s). Signalling at 300 c/s provides minimum impulse distortion of signals relayed by parent stations and frees the d.c. channels to satellite stations for inter-station telephone dialling.

From the G.C.C.'s the d.c. or 300 c/s channel is used to select visual telegraph and total-generation instructions and to make telephone calls. The same channel is used from the stations to indicate circuit-breaker operation, direction of telemetered power flow, acknowledgment of visual telegraph and generation instructions, and for telephone calling and clearing. To prevent lockout by heavy traffic, the common channel is used by the selection, indication and telephone trains in turn. Selection trains employ binary coding, with each variable comprising two complementary pulses—long and short or short and long. In addition, there is a 4-pulse code containing two marked impulses to select any one of six instructors. Proof of selection is based on total count and complementary pairing of the binary-code pulses. At the G.C.C. the point-indicating equipment for each line has a capacity of 240, in six groups of 40. The indicating trains, which are proved by total count, cater for the different groups of 40 points by means of a 4-pulse 6-group selection code and a marked pulse to steer the remaining 40 pulses to the indication relays; otherwise the signal train is switched to the telephone calling equipment. When an indication train is transmitted from a satellite station, it is relayed by the parent station, which, like the satellite stations, is prevented from transmitting. With an additional 4-pulse group-selection code, selection trains from the G.C.C. are relayed by the parent station into the local equipment or the particular satellite station as required.

Control Telephones

The Grid-control telephones at the stations are called with the minimum of pulses. The calling channel is not held during conversations, but talking proceeds with the called party holding himself to the line. This leaves the common channel free for subsequent priority calls, selections and indications, but it requires calls from the G.C.C. to be held until the called party answers or until a self-resetting delay circuit operates. At the conclusion of a call to the G.C.C. a simple code is sent from the station to clear down connections extended into office private automatic exchanges by telephone operators at the G.C.C. or Divisional headquarters. Control-telephone users at major stations can dial each other and can make direct calls to stations linked by the network. On engaged calls the user receives the 'busy' tone, but on calls to the G.C.C. control engineers he can exercise priority by dialling an extra digit. Priority calls disconnect non-priority parties, who then receive the 'busy' tone. Priority calls do not disconnect control engineers' conversations, but the G.C.C. control engineer



4 *Telemeter group*

is made aware of them by the calling lamp. The G.C.C. control engineers can call any Grid-control telephone—even though the telephone may already be engaged—and can throw off unwanted control telephones.

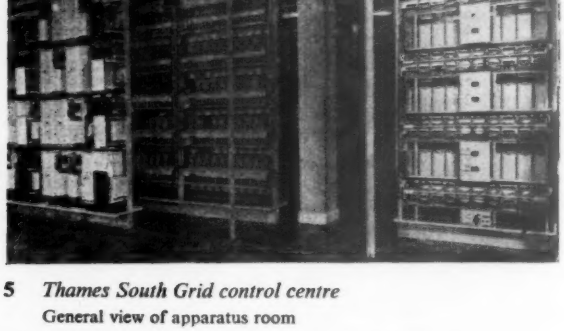
To ensure that a satisfactory speech level is always generally available, the over-all transmission loss is not permitted to exceed 20 dB to major stations, 25 dB to minor stations and 25 dB to major stations over tie-lines.

Minor stations use d.c. phantom-earth-return signalling for telephone calling and breaker indications to major stations. The minor-station telephones dial into a control-telephone connector at the major stations. The indication trains are decoded at the major station and retransmitted as if they were the major stations' own indications. When required, visual telegraph selections from the G.C.C. are decoded at the major station and retransmitted to the minor station as 300 c/s selection

trains. With a slight modification these 300 c/s selection trains are sent from control boards at major stations to operate the Grid switchgear at unattended minor stations, and the minor stations' indications are displayed on the control boards as well as at the G.C.C.

Telemeters

Single telemeters which monopolized signalling channels were superseded in the 1940's by systems which



5 *Thames South Grid control centre*
General view of apparatus room

catered for a number of telemeters on single channels. These multiplex systems served their purpose, but it was evident that telephone relays were unsuited for continuous multiplex telemetering. An electronic multiplex telemetering system was adopted for the standardized system, using simple time division, whereby 10 induction-type impulse meters, or the equivalent, are separately scanned every 300 millisec by a 10-way code sender. At the G.C.C. the decoded impulses operate electronic impulse-rate telemeters (Fig. 4) to produce direct voltages proportional to the impulse rates. Indication of direction of telemetered power flow is transmitted by the general indicating system as a point indication, thus releasing the full capacity of the multiplex signalling system for telemetering. A general view of the Thames South G.C.C. apparatus room is shown in Fig. 5.

Systems of intertripping, which have been widely used on the Grid-control networks since the early 1930's, have been outmoded by the introduction of 132 kV fault-throwers and direct point-to-point high-speed intertripping systems. A recent addition to the standardized system is the transmission of signals initiated by high-speed line protection to accelerate the operation of remote protection equipment or to unlock inhibited directional overcurrent at a remote transformer feeder station. Automatic frequency control is being developed as a possible future requirement for integration with the standardized system.

The standardized system is now in full operation in all control areas of the Central Electricity Generating Board. There is no doubt that, without standardization and co-operation between manufacturers, the G.P.O. and the Authority (now the C.E.G.B.), the re-equipment programme would have been impossible on both practical and economic grounds. 621.398 : 621.311.1

High-Temperature Effects on Flashover in Air

A synopsis of a Measurement and Control Section paper (2723) with the above title, by L. L. Alston, B.Sc.(Eng.), Ph.D., Associate Member. The paper is published this month in Part A of the Proceedings. Dr. Alston is with A. Reyrolle and Co. Ltd.

PASCHEN'S LAW HAS BEEN CONFIRMED EXPERIMENTALLY for millimetric gaps at up to 1100°C; flashover voltages obtained were independent of electrode material.

The effect of electrode hot spots at temperatures up to 1200°C was investigated in different electric fields, the bulk of the test gap being at room temperature. Under uniform-field conditions, hot spots caused a substantial lowering of flashover voltage, but their effect decreased as the divergence of the field increased. A hot spot in the region of least electric stress had no significant effect when the ratio of maximum to minimum stress exceeded a value of the order of, but greater than, the ratio of hot-spot to ambient temperature.

Evidence is advanced in support of the view that the operation of Trigatron gaps can be explained in terms of hot-spot formation. 621.387 : 621.316.57

Self-Extinction of Gaseous Discharges in Cavities in Dielectrics

A synopsis of a Measurement and Control Section paper (2730) with the above title, by E. C. Rogers, B.Sc., Graduate. The paper is published this month in Part A of the Proceedings. Mr. Rogers is with British Insulated Callender's Cables Ltd.

VARIATIONS OF DISCHARGE-EXTINCTION VOLTAGE OCCUR when a dielectric sample containing a single air-filled cavity is subjected to a 50 c/s testing voltage greater than that required to initiate discharges in the cavity. A particular aim of the investigation described in the paper was to determine the causes of self-extinction, whereby, under certain conditions, such discharges may spontaneously extinguish, even though the voltage applied to the sample may be several times the initial discharge-inception value.

The majority of the tests were made on polythene samples, but self-extinction of discharges has been observed with cavities in a number of other dielectrics. It is shown that the effect may be attributed to an increase in the conductivity of the cavity walls, induced by the discharges themselves. 621.315.61 : 621.317.32

COSMICAL ELECTRICAL DISCHARGES

From C. E. R. BRUCE,* M.A., D.SC., MEMBER

In 1944, I suggested[1a] that many astrophysical phenomena can be explained on the hypothesis that they are, or are the result of, electrical discharges in stellar or galactic atmospheres. Events since that date, such as the discoveries of radio astronomy and the determination of solar coronal temperatures of around 1 000 000° K, have emphasized the need for some such change in our ideas as I had suggested.

It may be of interest to record that the theory was initiated during Prof. Chapman's Kelvin Lecture about the sun on the 8th May 1941. From his description of solar prominences, and particularly their very high velocity of propagation, it seemed that the only possible explanation was that they are some form of electrical discharge.

The first main postulate was that large masses, of stellar dimensions and over, become surrounded by extensive tenuous atmospheres, that of the sun extending beyond the bounds of the planetary system. The second main postulate was that radial electric fields are set up in these atmospheres. It was suggested that many hitherto unexplained phenomena find an explanation on this basis. The sun's atmosphere for example, would possibly account among other things for cometary phenomena, as indeed Newall had suggested many years earlier, and for the F_2-layer of the ionosphere, while some magnetic storms could probably be explained in terms of electrical discharges propagated through the atmosphere, granted the existence of the electric field.

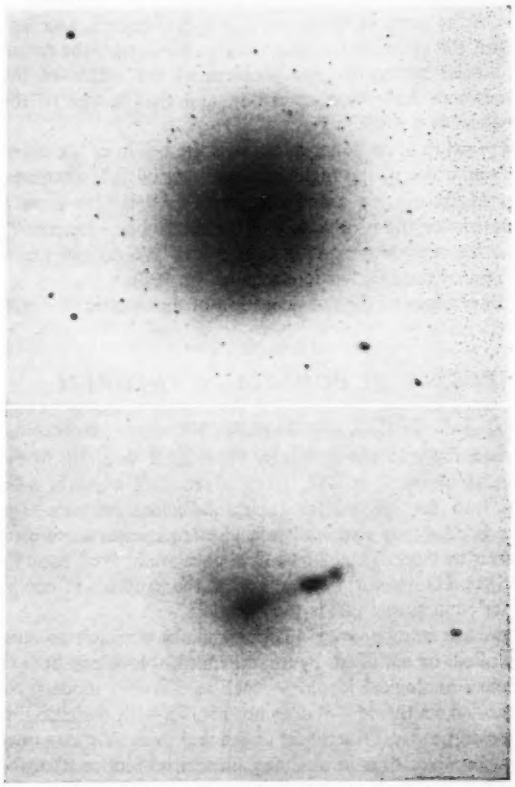
Since 1944 I have shown[1b,c] that there is a process which will lead to the generation of electric fields in these extensive gaseous atmospheres, namely asymmetrical impacts between solid particles. The only requirement is an adequate quantity of dust or grains, and this requirement is known to be fulfilled in both stellar and nebular atmospheres, and indeed in the latter the grains are known to be oriented in space, as they would be by an electric field.

The observed occasional excitation of the gas on both these scales in otherwise cold surroundings is such as would be caused by electrical discharges. Furthermore, the magnetic fields, to which these electrical discharges necessarily give rise, have been observed or deduced on both the stellar and nebular scales. In the Crab Nebula, indeed, Woltjer[2] has recently deduced that the polarization of the radiation can be explained on the assumption that electric currents flow along the gaseous filaments, so that the conclusion that these filaments are discharge channels would appear to be inevitable.

Recently too I have shown[1d,e,f] that the gas movements in the atmospheres of the long-period variable and combination-spectra stars are those to be expected if the outbursts are electrical discharges. The agreement between theory and observation is close over a range of 10 : 1 in velocity (10–100 km/s) and 100 : 1 in temperature (10000°–1000000° K). It is to be expected[1g] that a limit to this gas velocity will probably be reached when the conditions in the discharge channels become those productive of nuclear reactions.

In accordance with this view, the gas velocities observed to be associated with nebular discharges are of the order of thousands of kilometres per second, indicating the existence of temperatures of the order of hundreds of millions of degrees in the nebular discharge channels. The relationships between these gas movements in laboratory, terrestrial, and cosmical electrical discharges are discussed in a contribution[1h] to the conference on atmospheric electricity held recently in the United States. They are, for example, the basis of the arc-welding process.[3]

The discovery[1j] of the 'jet'—or discharge channel—in the globular nebula NGC 4486 (Fig. 1) likewise fulfilled a prediction made in the original work[1a] that electrical discharges will occur in this type of nebula. Confirmation of the nature of the 'jet' is afforded by the discovery that this nebula is a



1 *Photographs of NGC 4486 taken at the Mount Wilson and Palomar Observatories*

a 200 in. telescope; wavelengths $\lambda\lambda$ 3600–5000
b 100 in. telescope; enlargement of central regions, using wavelengths $< \lambda$ 4000
The length of the 'jet' is 300 parsec and its average width about 30 parsec (1 parsec = $19{\cdot}2 \times 10^{12}$ miles)

* Dr. Bruce is with the Electrical Research Association. His letter was originally received on the 14th October, and in revised form on the 28th October 1958

radio source.[4] It is shown in a recent report[1g] that the theory will account for many other outstanding characteristics of the extra-galactic nebulae, including the recently discovered existence of two stellar populations in spiral nebulae.

I would therefore suggest that the case for cosmical electrical discharges is now reasonably complete and that in many of these phenomena the electric field and its neutralization in electrical discharges play a role which exceeds in importance that of gravitation itself.

The recently published 'Proceedings of the third symposium on cosmical gas dynamics'[5]—Symposium No. 8 of the International Astronomical Union—affords abundant evidence of the difficulties which many of these observations present to existing theories and of the need for the introduction of the electric field and its neutralization in electrical discharges.

For example, the radio noise from external galaxies, such as NGC 4486, can be explained in terms of the movement of very-high-speed electrons in a magnetic field. Both these requirements are met by the electrical-discharge theory; without it, the position is rather different. One contribution to the above symposium contains a paragraph which raises hopes with the introductory sentence 'Among the many problems related to the Crab Nebula, the origin of the magnetic field is of the greatest importance in hydromagnetic studies'. However, the same paragraph closes (p. 1042) with the rather sad editorial comment 'The problem of the origin of the field seems to have been deferred'; and that is true of the symposium as a whole.

The position is no better as regards the origin of the other major requirement, the high-speed or 'relativistic', electrons. One contributor was asked categorically 'Do you have a mechanism for the production of the relativistic electrons?'. To this the reply was equally categorical 'We do not know the origin of the relativistic electrons' (p. 938).

In the absence of the consideration of the electric field and electrical discharges, the position is equally unsatisfactory when we consider the effects of one galaxy on another: for example, the effect of the Magellanic Clouds on our own galaxy. A question elicited the reply that this is greater by two orders of magnitude than any possible gravitational effect. But this came as no surprise to the speaker, who added 'We see such enormous distortions in many galaxies, and bridges between galaxies, and also more fancy things which cannot possibly be explained by gravitation, neither in order of magnitude nor even qualitatively in shape' (p. 925).

It is pointed out in the report[1g] cited that one of the most outstanding of these interactions between galaxies, the effect of NGC 3187 on the 'barred' spiral nebula NGC 3190, is at least qualitatively of the form to be expected on the electrical-discharge theory.

I wish to acknowledge with gratitude the encouragement I received from the late Dr. S. Whitehead and the way in which the E.R.A. Council have supported this work.

1 BRUCE, C. E. R.:
(a) 'A new approach in astrophysics and cosmogony' (London, **1944**)
(b) *Observatory*, 1955, **75**, p. 82
(c) *Philosophical Magazine*, 1955, **46**, p. 1123
(d) *Comptes Rendus*, 1956, **242**, p. 2101
(e) *Observatory*, 1957, **77**, pp. 107 and 153
(f) 'Etoiles à raies d'émission' (Proceedings of the eighth international astrophysical symposium, Liège, 1957) (Université de Liège, **1958**), p. 364
(g) 'Evolution of extra-galactic nebulae and the origin of metagalactic radio noise', *E.R.A. Report* **Z/T117**, 1958
(h) 'Terrestrial and cosmical lightning discharges', *E.R.A. Report* **Z/T119**, 1958
(j) *Philosophical Magazine*, 1958, **3**, pp. 539, 1328

2 WOLTJER, L.: *Bulletin of the Astronomical Institutes of the Netherlands*, 1958, **14** (483), p. 39

3 KING, L. A.: Paper to Physical Society's Conference on discharges in gases, Swansea, September **1958**

4 BAADE, W., and MINKOWSKI, R.: *Astrophysical Journal*, 1954, **119**, p. 215

5 *Reviews of Modern Physics*, 1958, **30**, pp. 913–1108

THE PUZZLE OF POYNTING'S THEOREM

From B. T. L. PRICE, ASSOCIATE MEMBER

HERE is a reply to the article by Prof. E. B. Moullin in the September *Journal*, p. 494, from a practical engineer who delves into the physics for their intellectual rewards. The article is of a type that inflicts a piquant mental torture on seekers after truth. Thus, in the final paragraph, Prof. Moullin says '[Mr. Hammond] has not solved the problem of energy transfer'; but surely this is the question.

There are many physical phenomena about which we must be satisfied, or mollified, by a mathematical ideology or by a piecemeal analogical ideology (such as Kelvin's models), so long as—like a thriller—it does not conflict with our credulity and we do not treat the model as the real thing. Yet one must be imaginative: thus in studying pulverized-fuel combustion the writer dwarfs himself like Alice. Now a turmoil of jelly-fishes are hurling themselves from all directions against honeycombed Gibraltars despite a fusillade of gleaming hot dyadic chainshot.

My idea of the Heisenberg uncertainty principle is of one worshipper in church, during the general declaration of faith, peeking to see whether another genuflects by ordinance. His very observance of another vitiates his observance of the faith.

Generalized co-ordinates present no logical difficulty if one does not attempt to put them into the geometrical pint pot. Mathematical orthogonality goes beyond graphics. One can accept the $i(CT)$ of relativity as a fourth graphic, yet when one asks a straight question—What is the radial limit to our expanding universe?—a rude reply would be more satisfying than a crooked answer about curved space.

Coming to the present subject, the writer, in his elementary way, finds Poynting's methods the logical conclusions from Maxwell's equations. A radiator is a pole; the energy of that pole can be integrated on a sphere around the pole. The resistance also, integrated to infinity, is in the immediate vicinity like that of an earth plate. Poynting and Maxwell postulated an ether, and the modernists have taken it away.

One is content to believe that cables are waveguides in which the electrons are counters for metering the energy of the Poynting vector field.

One wonders—Is Kelvin's ether still a satisfactory model? If not, what now is the medium for the energy fields of Faraday, Maxwell and Poynting?

OBITUARY

MERVYN O'GORMAN

Lt.-Col. Mervyn O'Gorman, C.B., D.SC., who was born at Brighton in 1871, died on the 16th March 1958. He was educated at Downside and University College, Dublin (which later made him an honorary D.Sc.). After graduating, he studied electrical engineering for two years at the City and Guilds College before joining Fowler Waring Cables Co. Subsequently, he was employed by Western Electric and the Glover Cable Co.

In 1909 he was appointed superintendent of H.M. Balloon Factory, Farnborough, and remained there until it became the Royal Aircraft Factory in 1916, when he became consulting engineer to the Director-General of Military Aeronautics. O'Gorman did not receive adequate recognition for his work at Farnborough. There can be no doubt that he laid the foundations on which the present Royal Aircraft Establishment was built and that he was the man who brought science to the sport of aeronautics. He gathered under him in the early years of the First World War an incomparable team, which included such people as Lord Cherwell, Sir George Thomson, Professor Aston, Major F. M. Green, Sir Melville Jones, H. P. Folland, Hugh Burroughes, C. S. Rolls and Sir Geoffrey de Havilland and dozens who afterwards became the life-blood of the British aircraft industry.

When he first joined it, the Balloon Factory was experimenting with balloons and man-lifting kites and was run by soldiers. O'Gorman decided, in the face of opposition from the War Office, to engage practical engineers and scientists and start experiments with aeroplanes. Often, parts of older machines had to be used as a basis for building a machine of entirely new design. The first B.E. biplanes were certainly not 'new' but were reconstructed from old wrecks.

O'Gorman served on a committee whose report resulted in the constitution of the Royal Flying Corps in 1912, and he was given the rank of lieutenant-colonel in the Corps in 1916.

After 1920 his work mainly concerned motoring problems, but he retained his close interest in aviation, serving as vice-chairman of the Royal Aero Club, chairman of the Accidents Investigation and Civil Air Transport Committee of the Air Ministry, and vice-president of the Fédération Internationale Aéronautique. From 1919 to 1929 he was chairman of the Adhesives Committee of the Department of Scientific and Industrial Research; from 1923 to 1931, he was vice-chairman of the Royal Automobile Club and vice-president in 1952.

He was an artist of no mean achievement, and his lacquer work and drawings were of a high order.

He was honorary secretary of the Students' Section of The Institution in 1894 and was elected an Associate in 1895 and a Member in 1898. He received the Institution Premium in 1901 for his paper entitled 'Insulation on cables' which was published in the *Journal*. He served on the Council from 1906 to 1909. In his will, he left the sum of £2000 unconditionally to The Institution, for use as the Council may see fit; and they have accepted the legacy with gratitude for the thought for The Institution which prompted his bequest. He was also a Member of The Institutions of Civil Engineers and of Mechanical Engineers. He was appointed a Companion of the Order of the Bath in 1913.

SYDNEY ARTHUR JOYCE

Sydney Arthur Joyce, who was born in Derby on the 2nd January 1886, died on the 27th September 1957. He was educated at the Muncipal Elementary School, Derby, and received his engineering education part-time at Derby Technical College and the Manchester School of Technology, with practical training at the Calvert Street power station of the Midland Railway Co. In 1903 he entered a four-year apprenticeship at the Trafford Park works of the British Westinghouse Co.

In 1907 he was transferred to the Cardiff office of the company and later that year was appointed resident sales engineer to the Swansea district, where he remained until 1913, when he left to work for the company in India as manager of the Calcutta branch office.

This was followed by a move to New Zealand in the early 1920's. By this time the company had become Metropolitan-Vickers Electrical Co., and it was for this organization that Joyce acted as manager for New Zealand, based in Wellington. He returned to England in 1930 for health reasons and shortly afterwards retired on medical advice.

In all his undertakings Joyce was a most diligent and kindly man, with a capacity for making and helping friends. During his long years of disability, from his premature retirement until his much lamented death, he retained contact by correspondence with his many friends at home and oversea. He was an ardent philatelist, and this provided a ready means for keeping in touch. He is survived by his widow and a married daughter.

He joined The Institution as a Student in 1905 and was elected an Associate Member in 1912 and a Member in 1917. F. J. E. T.

JOHN SCOWCROFT RAMSDEN

John Scowcroft Ramsden died at Eastbourne on the 22nd February 1958, after several years of indifferent health following his retirement in 1950. He was born at Bolton on the 22nd July 1884 and received his early technical education in Bolton and later at the Manchester School of Technology. After an apprenticeship with Dobson and Barlow Ltd., Bolton, he joined the British Westinghouse Co. at Manchester as a draughtsman in the switchgear and control-gear department. After further experience with the Electric and Ordnance Accessories Co. (Vickers Ltd.) and with the Millwall Electric Co. Ltd., in 1910 he joined the British Thomson-Houston Co. Ltd., Rugby, as a control-gear draughtsman.

Ramsden remained with the British Thomson-Houston Co. for the rest of his working life, during which time he rose, by successive stages, from the drawing office to the board of directors. In 1911 he became a sales engineer in the supply department and progressed via the Manchester and Birmingham district offices to the managership of the department by 1923. In 1932 he was made responsible for the industrial sales department and the BTH district offices in the United Kingdom. In this period of intense competition, he took a leading part in securing the co-operation of other British manufacturers in the mitigation of uneconomic marketing of electric motors and control gear. He was appointed to the BTH board in 1935 and became general sales director in 1943. In addition, he was a director of several associated companies and was for many years on the Council of the British Electrical and Allied Manufacturers' Association.

He will be remembered for his human touch in industry, rather than for the positions he attained. Known affectionately by his colleagues and staff as J. S. R., he represented to them a source of wisdom, of fair treatment, and of understanding of their personal viewpoints and aspirations. They would confide in him and seek advice or help beyond the boundaries of their day's work.

His interests were varied and his hobbies simple. They ranged from amateur operatics and gardening at an early age, to professional boxing and bowls later. But above all, he was interested in people rather than in things; and he held office in most of the BTH staff recreational and welfare societies.

To his wide circle of friends it seemed that his retirement brought him undeserved troubles of ill-health and bereavement, which he needed all his courage and patience to endure. He is survived by his widow but was predeceased by their only son.

He joined The Institution as an Associate Member in 1920 and was elected a Member in 1927. He served on the South Midland Centre Committee from 1938 to 1941. W. S. S.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as these separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.

Applications, quoting the serial number of the paper, monograph or reprint, as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually—if they do not take the Part of the Proceedings in which it will be republished—are urged to apply in due course for a reprint, as this is the final and correct version and includes the discussion.

PAPERS

Silicone electrical insulation *Paper* 2814 M: *Part A*

J. H. DAVIS

SILICONE fluids, greases, rubbers and resins, either alone or in combination with inorganic insulating materials, are described in terms of their chemical structure and physical properties.

After a brief review of thermal-endurance evaluation and the status of silicone insulation in British and other standards, with particular reference to Class H, the applications of the insulation are discussed with reference to conductors, cables, rotating machines, transformers, and other electrical apparatus.

Although silicones are considerably more expensive than common organic materials used for lower-temperature insulation, the increased cost is often justified by a relatively small effect on the over-all cost of the complete apparatus and a compensating improvement in performance or reliability, or, in some cases, an over-all saving in installation cost.

The author discusses desirable improvements in present-day silicones, particularly in physical properties and processing. The trend towards using silicones in equipment formerly insulated with Class-B materials will continue, though cost will limit their employment in lower-temperature apparatus.

To be read on the 6th January 1959

Design of electro-mechanical auxiliaries directly associated with power-producing reactors *Paper* 2812 S: *Part A*

A. E. HARWOOD, P. SCOTT, M.A., *and* B. H. STONEHOUSE, B.SC.(ENG.)

THE paper deals with the novel problems encountered in the design and construction of the electro-mechanical plant directly associated with the reactor in a base-load nuclear-power station of the gas-cooled, graphite-moderated natural-uranium type. The problems arise from the fact that the plant must operate in radioactive areas, and certain parts of it are immersed in the reactor coolant.

Two distinct features are considered: the materials of construction and the control of the plant. The materials are required to be resistant to the effects of radiation and temperature and must be compatible with the coolant.

The features required by the operator for controlling the plant from a remote point and the need for the highest possible reliability are considered.

To be read on the 28th January 1959

Electrical supplies to power-station auxiliaries *Paper* 2759 S: *Part A*

D. A. DEWISON

THE general principles of the unit-transformer system are described, and the detailed design problems and economic aspects associated with the system are examined. The theme is illustrated by an example of a station comprising five 200 MW units.

Due for reading in the second half of the session

Development of high-voltage air-break circuit-breakers with insulated-steel-plate arc chutes *Paper* 2746 S: *Part A*

F. S. FAY, M.A., J. A. THOMAS, B.SC., D. LEGG, B.SC., *and* J. S. MORTON, B.SC.

THIS is a report of research over the past ten years to investigate the principles of operation of a.c. air-break circuit-breakers for voltages up to 15 kV and breaking capacities up to 500 MVA. Much of the information on contacts, arc runners, the behaviour and control of arcs in arc chutes, and arc extinction is of a fundamental nature and suitable for general application. High-speed photography played an important part in obtaining the data. The arc chute finally developed is of the insulated-steel-plate type, without blow-out coil.

The results have been applied to the design and manufacture of air-break circuit-breakers with British ratings up to 250 MVA at 3·3 kV, and up to 400 MVA at 6·6, 11 and 15 kV, and American ratings up to 750 MVA. Details are given of the performance of the circuit-breakers and the effect of the system characteristics.

Development is continuing to higher voltages and ratings.

Due for reading in the second half of the session

Design of electromagnetic pumps for liquid metals *Paper* 2763 U: *Part A*

D. A. WATT, B.SC.(ENG.)

THE practical design of electromagnetic pumps is discussed with particular reference to the construction of the duct/electrode element. Common features of electrical design are explained in terms of a simple theory of tube efficiency.

The scope of d.c. pumps in meeting different duties and practical conditions is shown. Some results of an experimental investigation of d.c.-pump performance in a 4 in.-diameter pipe loop are given. The significance of end-current loss is indicated, as well as the equivalent reduction effected by the presence of a graded fringing field in the end regions. A technique of electrode 'wetting' suitable for mercury and stainless steel is described, together with gas-entrainment experiments.

A homopolar generator with mercury collector rings is considered. This type of machine would provide an efficient

source of current for the d.c. pump. The newer types of rectifier are briefly compared with the generator for this application.

Reference is made to polyphase travelling-field pumps, and their appropriate application is discussed. Simple theory of design is presented, with relationships for optimum design at standard supply frequency.

Other possible designs of large electromagnetic pump are briefly examined and compared with the basic forms of conduction and induction pump.

The various classes of pump suitable for laboratory use are mentioned, and general principles of selection are offered.

Date for reading not yet fixed

Examples of geoelectrical surveys *Paper* 2791 M: *Part A*

L. S. PALMER, D.SC., PH.D.

THE introduction deals briefly with the general principles underlying geoelectrical methods of surveying and gives a simple formula for the apparent resistivity at a given depth below the surface in a homogeneous medium. The two problems of interpreting the different kinds of curves obtained from field measurements and of determining the depth of the associated geological anomalies are examined.

The electrical equipment and field procedure are briefly described. Three particular anomalies are considered:

(i) Parallel strata as illustrated by the boulder-clays which overlie the chalk of the Holderness Plain, East Yorkshire
(ii) Inclined strata which occur where the water-table reaches the surface on the slopes of the Mendip Hills, Somerset
(iii) A cavern in the limestone rocks at Pen Park near Filton, Bristol.

The relevant equations and the geoelectrical measurements and graphs, together with their interpretations, are discussed. The equation for inclined strata is deduced in a form comparable with the previously published equations for parallel strata and a spherical cavity. It is concluded that no ancient Humber estuary existed in the chalk beneath the boulder-clays, but the presence of an interglacial gravel separating two deposits of boulder-clays is established. The water-table is located and is found to emerge along a line of springs which coincides with the edge of the conglomerate deposited by the ancient Triassic sea.

The deductions made were verified by subsequent excavations which led to the rediscovery of Pen Park Hole.

The derivation of the equations for a homogeneous medium, for parallel strata and for a buried sphere is given, as well as theoretical relationships for calculating the depths of these particular anomalies

Date for reading not yet fixed

System for automatic recognition of patterns
Paper 2792 M: *Part B*

R. L. GRIMSDALE, M.SC., PH.D., F. H. SUMNER, B.SC., PH.D., C. J. TUNIS, B.ENG., M.SC., PH.D., *and* T. KILBURN, M.A., PH.D., D.SC.

A NEW method is described for the automatic recognition of patterns. The method may be applied to any form of spatial pattern, but in the present instance patterns consisting of line figures are considered. The pattern is presented to a flying-spot scanner connected to a digital computer. The shape of the pattern is analysed, and a statement is prepared describing the basic features of the pattern. The pattern is then recognized by comparing this statement with a number of others already stored in the computer which relate to named patterns.

Patterns are recognized independently of the angle at which they are presented to the scanner and may be of any size provided that limits imposed by the resolution of the scanner are not exceeded. The average time to recognize a character is 60 seconds with the system programmed on a medium-speed computer. Special-purpose equipment built to perform certain of the stages of the process, together with the use of higher-speed computers now envisaged, will reduce this time by at least a thousandfold.

If a new pattern is presented, the machine indicates inability to recognize, but giving the machine the name of the pattern may result in its becoming one of the standard patterns which the machine can subsequently recognize. All the patterns recognized by the machine are hand-drawn and consist of such symbols as the capital letters of the alphabet and numerals, although the system is in no way limited to any special set of characters. Using exactly the same method but with an increase in the degree of complexity, it will be possible to recognize handwriting.

Special allowances are made for imperfections in the patterns, including breaks and general ill-definition. Where there is some confusion and an unknown pattern resembles two or more of the standard patterns, the relative degrees of similarity of the unknown to each of these standard patterns are printed out by the machine.

Date for reading not yet fixed

Electron-trajectory tracer for use with resistance-network analogue *Paper* 2800 M: *Part B*

M. E. HAINE, D.SC., *and* J. VINE, M.SC.

A DESCRIPTION is given of an instrument providing for direct analogue computation of electron trajectories, a resistance network providing the necessary field data. Constructional details are given, and results for two typical electrostatic lenses are shown and compared with results obtained experimentally. Methods for improving accuracy and speed of operation are outlined.

Date for reading not yet fixed

The Editor regrets that Paper 2781 M was wrongly recorded in the November 1958 issue of the Journal. The correct title and synopsis are published below

Power-system automatic frequency-control techniques
Paper 2781 M: *Part A*

F. MORAN, M.SC.

THE main reasons for the adoption of automatic-control techniques in power systems are given, and the position on their application to the British Grid system is stated. The behaviour of speed governors in a manually controlled system, leading to the development of the electrical governor, is discussed, and a Swedish governor of this type is described. The need for mixed power-frequency control and the merits of frequency-bias tie-line control are considered. A distinction is made between automatic control which only trims manual load dispatching and fully automatic loading schemes. The necessary elements of automatic control are next mentioned, and as examples of precision frequency meters, British and German developments are examined. Alternative methods of achieving desired participation in regulation are related, and particulars are given of a scheme developed in

Britain, including details of the machine controllers and system controller. Some test results are presented.

The use of system simulators is explained, and British and German simulators are described.

Read on the 2nd December 1958

Application of junction transistors to audio-frequency telephone line amplifiers *Paper* 2764 R: *Part B*

H. G. BASSETT, B.SC.(ENG.), D. THOMSON *and* P. E. GREENAWAY

THE application of the alloy junction transistor in a.f. telephone line amplifiers requires good linearity and constancy of gain, and stability of input and output impedances. A single-stage push-pull amplifier using mixed feedback has a performance approaching that of a standard thermionic-valve line amplifier but requires individual adjustment of the feedback paths. In order to duplicate a standard thermionic-valve line amplifier without recourse to individual adjustment, two stages are necessary, and two such amplifiers are described.

To be read on the 5th January 1959

MONOGRAPHS

Comparison of Millington's method and equivalent-numerical-distance method with theory of ground-wave propagation over inhomogeneous earth *Monograph* 318 R

Z. GODZIŃSKI

MILLINGTON'S method may be used in most practical problems of ground-wave propagation. For overland paths, the errors of the method are very small; for land–sea paths they may be larger: up to about 2·7dB for 2-section paths, up to about 5·5dB for 3-section paths, and up to about 2·5dB for each land–sea boundary for very long paths.

In most cases, the equivalent-numerical-distance method shows considerable errors. It may be used for paths representing small numerical distances, especially for overland paths. It may be applied to longer paths when the electrical parameters of the sections are insignificantly different.

Effect of temperature on persistence of long-persistence cathode-ray-tube screens *Monograph* 320 R

R. FEINBERG, DR.ING., M.SC.

THE persistence characteristics of several types of long-persistence cathode-ray-tube screen were measured with the ambient temperature of the tube faces varying from about 20° to about 50°C. Increasing temperature reduced the persistence time, the temperature coefficient of persistence-time reduction being higher for some types and lower for others. In some cases, temperature coefficient also decreased with increase in excitation luminance.

Effects of argon content on characteristics of neon–argon glow-discharge reference tubes *Monograph* 321 R

F. A. BENSON, D.ENG., PH.D., *and* P. M. CHALMERS, B.ENG.

MEASUREMENTS were made of the influence of varying the argon content of certain glow-discharge stabilizer tubes on the running-voltage/current and running-voltage/temperature relationships, the initial drifts, and the impedance-frequency and noise characteristics. Neon-filled tubes, with argon contents varying over the relatively wide range 0·001 to 10% and with molybdenum anodes and cathodes, were specially constructed for the investigation using high-stability reference-tube-manufacturing techniques.

Comparison of transient response of amplitude-modulated and frequency-modulated signals *Monograph* 322 R

S. J. COTTON, B.SC.

THIS is an analytical investigation of the transient response of resistance-capacitance and resistance-inductance circuits, filters and transmission lines to a frequency-modulated voltage, using a unit-step function as modulating signal.

The transient response is compared with that which is known to occur when the voltage is amplitude-modulated, using the same modulating signal. The effects, on the response, of the bandwidth of circuits subsequent to the detector stage of a receiver are compared for the two types of modulation.

Forthcoming Events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION
R RADIO AND TELECOMMUNICATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal*.

January 1959

R **5** *Monday* H. T. PRIOR, B.SC., D. J. R. CHAPMAN, B.SC., *and* A. A. M. WHITEHEAD, B.SC. 'Application of transistors to line-communication equipment' (Paper 2722 R) *synopsis:* September 1958

H. G. BASSETT, B.SC.(ENG.), D. THOMSON *and* P. E. GREENAWAY, B.SC. 'Application of junction transistors to a.f. telephone line amplifiers' (Paper 2764 R) *synopsis:* see this page.

MU **6** *Tuesday* J. H. DAVIS 'Silicone electrical insulation' (Paper 2814 M) *synopsis:* see p. 672

O **8** *Thursday* C. O. BOYSE, B.SC.(ENG.). First Hunter Memorial Lecture : 'P. V. Hunter—electrical engineering in our time'‡ (see p. 687)

I **12** *Monday* P. F. CLARK will open a discussion on 'What is the economic limit of mechanical aid to field work?'*

E **13** *Tuesday* Two members of the London Graduate and Student Section will open a discussion on 'Education and training from the student's point of view'* (Joint Meeting with the London Graduate and Student Section; at 6.30 p.m., tea at 5.45 p.m.)

U **15** *Thursday* (in conjunction with the British Nuclear Energy Conference) N. J. MACKAY *and* E. HARDWICK 'Electrical installation at Calder Hall nuclear power station' (Paper 2699 U) *synopsis:* August 1958

U **16** *Friday* Section Dinner-Dance (at the Café Royal, at 7 for 7.30 p.m.)

R **19** *Monday* A. H. W. BECK, B.SC.(ENG.) 'High-current-density thermionic emitters' (Paper 2750 R) *synopsis:* November 1958

M **20** *Tuesday* K. KANDIAH, M.A., will open a discussion on 'D.C. amplifiers'†

R **21** *Wednesday* C. G. GARTON. Lecture on 'Dielectric materials—trends and prospects'†

O **22** *Thursday* D. A. BARRON, M.SC. 'Subscriber trunk dialling' (Paper 2795 R) *synopsis:* November 1958

26 *Monday* H. A. THOMAS, D.SC. The Faraday Lecture: 'Automation'‡ (at the Royal Festival Hall, London, at 6 p.m.; admission by ticket available on receipt of a stamped addressed envelope)

S **28** *Wednesday* (in conjunction with the British Nuclear Energy Conference) A. E. HARWOOD, P. SCOTT, M.A., *and* B. H. STONEHOUSE, B.SC.(ENG.) 'Design of electro-mechanical auxiliaries directly associated with power-producing reactors' (Paper 2812 S) *synopsis:* see p. 672

R **29–30** *Thursday–Friday* Convention on 'Long-distance transmission by waveguide' (all wishing to attend are required to register; full details and registration form obtainable from the Secretary)

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report C/T120 **Windmills for Electricity Supply in Remote Areas** by G. Gimpel and A. H. Stodhart. 18s. (postage 6d.)

THIS report deals with the economic and technical requirements for windmills used as a source of electrical energy in areas distant from main distribution networks.

A range of suitable ratings is recommended, and the preferable features of the main components of a windmill are indicated.

Report F/T186 **Methods for the Calculation of Cyclic Rating Factors and Emergency Loading for Cables Laid Direct in the Ground or in Ducts** by H. Goldenberg. 5s. (postage 6d.)

THIS is a summary, in a convenient form for practical use, of the methods described in detail in report F/T184. Proofs of the formulae are omitted here but can be found in the original document. It is a companion to report F/T183, published in 1955, which contains tables of continuous current ratings and rating factors for cables up to 33 kV conforming to B.S. 480: 1954 and B.S. 608: 1955.

Report F/T187 **The Calculation of Continuous Current Ratings and Rating Factors for Transmission and Distribution Cables** by H. Goldenberg. 27s. (postage 8d.)

THIS combines the detailed method of current-rating calculation given in report F/T131 with the modifications used in the calculation of figures presented in report F/T183. The present report concludes with methods of calculating current ratings for various types of h.v. cable other than solid.

Report G/T311 **The Temperature Rise of the Terminals of Plugs and Socket Outlets to B.S. 1363: 1947, with Special Reference to Adaptors** by H. W. Baxter. 6s. (postage 4d.)

THESE adaptors are required by the Institution Wiring Regulations to be fitted with a fuse of maximum rating 13 amp, but it was thought that the heat produced by the fuse would result in a higher temperature rise of the socket contact than would occur with a non-fused adaptor. This report gives results of investigations into the temperature rise associated with both types.

Report L/T351 **The Electrical Properties of Tungsten Trioxide (Final Report)** by J. Hirsch. 10s. 6d. (postage 4d.)

THIS is a continuation of report L/T326. It describes the preparation and the electrical properties of WO_3 in ceramic form, using denser specimens than were achieved in the earlier work. It is concluded that the material is much too conductive to be of practical interest as a dielectric. The conductivity is decreased by some additives, but not sufficiently to render the material useful. No electrical hysteresis could be detected. (See June *Journal*, p. 330.)

Report L/T360 **The Polymerization of Organic Compounds by Ionizing Radiation** by C. E. King. 7s. 6d. (postage 4d.)

THIS report describes an investigation into the possibility of polymerizing organic materials (in particular, aromatic hydrocarbons) by the action of high-energy radiation. The source of energy was chiefly an electrical discharge, but a linear accelerator was also used. An account is given of the types of material so obtained.

Report L/T364 **The Effects of Small Discharges on Some Insulating Materials. 2—At Atmospheric and Reduced Pressures** by N. Parkman. 18s. (postage 7d.)

THE behaviour of alkyd and phenolic thermosetting mouldings when discharges impinge upon them has been investigated. The effects of surface area and conductivity on discharge magnitude and life were examined. Results of measuring the frequency spectrum of discharges are used to predict the area discharged instantaneously as a function of surface conductivity.

Report M/T126 **Interference between Power Systems and Telecommunication Lines** by H. R. J. Klewe (Edward Arnold Ltd., London, 1958). 70s.*

IN this book all the information that is available has been brought together. After introductory chapters on the historical aspects of interference investigations and the theory of coupling between circuits, the effects and causes of interference and methods of reduction are dealt with in detail. Nearly 30 pages are concerned with practical calculations and examples, and the comprehensive bibliography is cross-indexed.

Report N/T77 **An Investigation into the Causes of Excessive Iron Losses in Electrical Machines** by D. A. Jones. 10s. 6d. (postage 6d.)

THE purpose of the investigation described in this report was to develop a method of measuring the iron loss of stator cores before they are wound and to discover the cause of the variation in iron loss which occurs between apparently similar machines. Most of the investigations were carried out on the stator cores of a water-cooled induction motor.

Report N/T78 **An Electrical Analogue of Magnetic Domains** by P. F. Davis. 4s. 6d. (postage 6d.)

THIS report describes an electrical analogue for elucidating the domain structure in a picture-frame specimen of a single crystal of iron. This analogue can be used for finding either the magnetic energy or the field associated with a domain structure. Two forms of the analogue are described.

* This report can be obtained by members of the British Electrical and Allied Industries Research Association from the Publication Sales Department of the Association at Thorncroft Manor, Dorking Road, Leatherhead, Surrey, and by non-members from the publishers

Report O/T19 **The Movement of an Arc Between Parallel Horizontal Rods Fed from One End, in Still Air and in a Wind** by A. E. Guile. 12s. (postage 4d.)

THE author describes the first stage of an experimental investigation carried out at Queen Mary College, University of London, into the effectiveness of arcing devices on high-voltage insulators. Further stages of the work cover the protection of insulators on systems up to 33kV from damage by arcs, particularly in windy conditions.

Report V/T132 **Data Required for the Solution of Power System Problems** 6s. (postage 6d.)

THIS report tabulates all the items on which data are required before analysis begins, including those relating to synchronous machines, transformers, cables, overhead lines, system operation and other studies.

Report W/T34a **An All-Electric Multipurpose Farm Drier: Design and Operation** by P. Finn-Kelcey and V. M. Owen. 2s.* (postage 6d.)

GIVES full details of a typical multi-purpose drier, based on earlier E.R.A. experiments, which was in operation on a Hampshire farm during 1954–56, and concludes with a discussion on the application of this method of drying to farming conditions in Great Britain.

Report Y/T21 **Failures of Domestic Immersion Heaters Caused by Corrosion and Scale Formation—Résumé of Literature and Assessment of Economic Importance in Great Britain** by A. Morris Thomas. 21s. (postage 6d.)

THE report consists of a résumé of published work on metallic corrosion and scale formation, with special reference to the performance of domestic immersion heaters; and the results of a statistical survey of immersion-heater failures in Great Britain, analysed with respect to water hardness.

Report Z/T112 **Arc and Bead Characteristics for Pure Aluminium for a Range of Wire-Feed Rates (Self-Adjusting Arc) at a Constant Voltage in Argon** by J. C. Needham and A. A. Smith. 12s. 6d. (postage 8d.)

A DESCRIPTION is given of carefully controlled weld tests made over a large range of wire-feed rates, at constant arc voltage. The significance of the metallurgical and electrical features is discussed in relation to the arc and bead characteristics.

Overseas Newsletter

WITH the setting up of an Overseas Liaison Department, the Association has prepared a new journal, *Overseas Newsletter*, for distribution to its members oversea. The first issue has just been published, and further issues will be sent out at 6-monthly intervals, in March and September. Each will include a summary of the current research programme, with emphasis on topics of interest oversea, brief notices of past and forthcoming electrical-engineering meetings, and short reviews of books, technical papers and recent British developments.

ELECTRICITY COUNCIL

Utilisation Research Report No. 8 **A Sample Survey of Commercial Consumers** London, 1958

RESULTS given in this report were obtained from a sample of 5000 consumers and apply, on average, to the year 1953. Detailed analyses show that 22% of the consumers used less than 500kWh/year, and less than 10% used more than 10 000kWh/year. Half of the consumers accounted for only 7% of the total consumption and 9% of the total revenue. About 55% of the total consumption was attributable to lighting and 25% to space heating, but the annual consumption per kilowatt installed was twice as high for lighting as for space heating.

HOKKAIDO UNIVERSITY

Monograph Series of the Research Institute of Applied Electricity, No. 6 **Microwave Propagation in Snowy Districts** by Y. Asami (*Editor*). Hokkaido University, Sapporo, Japan, 1958

THIS booklet contains papers on the reflection of microwaves in snow-covered districts, the weather conditions under which ice and snow accretion occur, the electromagnetic effects due to ice and snow accretion on microwave antennae, and the prevention of damage to antennae by ice and snow.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Notes on Applied Science No. 19 **Signal Generators, Attenuators, Voltmeters and Ammeters at Radio Frequencies** National Physical Laboratory. H.M.S.O., 1958. 1s. 6d. (postage 2d.)

THIS note deals primarily with the measurement of attenuation in the region between audio and microwave frequencies. This involves the power or voltage ratio which is required for calibrating a signal generator and for investigating the variation with frequency of a voltmeter indication. The frequency dependence of current-measuring devices has also been included.

Road Note No. 23 **Vehicle Headlamp Testing** Road Research Laboratory H.M.S.O., 1958. 2s.

THIS report describes the types of headlamp and auxiliary lamp currently in use and shows how faults can be discovered and corrected. A brief survey of present-day beam-checking equipment is given in the appendix.

MINISTRY OF DEFENCE

Defence Specification DEF-33 **The Preparation of Drawings for Service Equipments** H.M.S.O., 1958 7s. 6d.

THIS specification supplements the recommendations of B.S. 308: 1952, 'Engineering Drawing Practice', and includes recommendations for drawing procedure. It is the intention of the Services to have all drawings of their equipments prepared in accordance with these specifications.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

The European Nuclear Energy Agency of the O.E.E.C. Structure and Functions: First Joint Undertakings. Paris, 1958

THIS illustrated booklet contains a summary of events leading to the formation of the European Nuclear Energy Agency, and states its structure and functions. The development work being carried out on Eurochemic, experimental reactors and future joint undertakings is also described.

* For quantities there is a reduction in price, e.g. 250 copies for £20

SOME RECENT BOOKS

S. W. BELL AND H. MATLEY

MATHEMATICS FOR HIGHER NATIONAL CERTIFICATE. VOL. 2

CAMBRIDGE. 1958. 486 PP. 35S.

THIS book is primarily intended to cover the study of mathematics in the final year of the Higher National Certificate in Electrical Engineering and to present sufficient further work to form the basis of a more advanced mathematics course for electrical engineers. It therefore invites comparison with a number of other textbooks on engineering mathematics which have appeared during the past few years and which cover much the same ground.

The present volume differs chiefly from others in dealing with a wider variety of applications of mathematics to electricity, including information on symmetrical components and on inversion and its application to current loci, and chapters on the elements of matrix algebra and on the application of matrices to network analysis. These are welcome features in the book, which also covers satisfactorily topics common to most A.2 syllabuses, such as differentiation, partial differentiation, integration, complex variable, first- and second-order differential equations, simultaneous linear differential equations, determinants, and Fourier series.

Other subjects treated, some of which are at times also studied at the A.2 level, comprise an introduction to the series solution of differential equations, the solution of differential equations by the Laplace-transformation method, an introduction to the solution of partial differential equations, and double integrals. This is a fairly comprehensive list, but space should have been found for such matters as the method of least squares, interpolation, and the elements of vector analysis, all of which are found, though not very commonly, in A.2 syllabuses.

There are adequate worked examples in the text; and the answers to the exercises contain, where appropriate, hints on method, a feature which should be helpful to advanced students, to whom the book can certainly be recommended.

The book may also prove useful to the qualified engineer as a work of reference, at the level indicated above, for standard mathematical techniques, applicable to a number of electrical problems. However, it is not completely self-contained for this purpose, for Fourier series are introduced in Vol. 1, so that a complete account is not found in Vol. 2, while the catenary is dealt with in Vol. 1 only.

F. J. BIONDI (*Editor*)

TRANSISTOR TECHNOLOGY. VOL. 2

VAN NOSTRAND. 1958. 701 PP. £6 11S. 6D.

THE review of Vol. 1 of 'Transistor technology' (September *Journal*, p. 512) looked forward, with great expectations, to Vols. 2 and 3, which were to include details of the many advances since 1952 leading to the design of transistors of high performance and to their economic and large-scale production. The expectations were based on the wealth of knowledge of the Bell Telephone Laboratories and the Western Electric Co. and the undoubted ability of many of their authors to present technical information in a clear and interesting way.

But Vol. 2 turns out to be little more than a collection of post-1952 articles, most of which appeared in readily accessible journals. Very few afterthoughts or connecting paragraphs are included. References back are rare, and the papers are not arranged in chronological order, even within chapters; thus in chapter 4 (Diode-design principles) the dates of publication of the papers included are, in the order in which they appear, 1956, 1953, 1954, 1954, 1956, 1954.

Exception might also be taken to some of the subject-matter included, according to one's interpretation of the title of the book. The preparation of semiconductors is given some space, but transistor-manufacturing processes very little; very much more room is devoted to the principles of design and the analysis of behaviour (small signal, large signal, transient, high frequency) of diodes and transistors, including the unipolar transistor, and to describing and interpreting some important, if no longer the most recent, studies of surface phenomena (mostly removed from manufacturing processes).

There is therefore a persistent strong flavour of electrical science which engineers will applaud; moreover, when one has accepted the range of subjects included, there can be little to quarrel with in the choice of articles made, for older workers will recognize many as worthy landmarks—full of facts, theories and proposals.

It is almost unnecessary to say that any book in the Bell series is very well presented; this one certainly is. But the work of over 40 authors aimed at different specialist audiences at different times could surely have been given new life in more balanced accounts, with comments appropriate to 1958, by a much smaller number of authors.

D. BURN (*Editor*)

THE STRUCTURE OF BRITISH INDUSTRY. VOL. 2

CAMBRIDGE. 1958. 499 PP. £2 10S.

THIS is the second part of a symposium on the structure of ten selected British industries, to each of which some 30 to 60 pages are devoted. Had the editor thought fit to group the industries, there would have been three sections in this part: one dealing with engineering, embracing the motor, aircraft, shipbuilding and electronics industries; another concerned with cloth making, introducing the cotton and rayon, woollen and worsted, and man-made fibre industries; and the last a miscellaneous section covering the pottery, cutlery and pharmaceutical industries.

A symposium depending on a number of contributors requires clear initial briefing of the authors, followed by a strong editorial hand. Unfortunately, the editor of this series seems to have regarded as his main duty that of providing a summing-up of the points made by the separate authors; excellent though this finale is, it cannot make up for lack of a

clear editorial policy. Thus Rainnie begins his chapter on the woollen and worsted industry by (quite correctly in the reviewer's opinion) 'eschewing any attempt to embark on even the briefest historical introduction, using the evidence of history only where otherwise the present would remain obscure or ill-explained, and concentrating on attempting to draw the structure'. On the other hand, Wilson devotes 12 of his 60 pages on the electronics industry to a sketch of the history of radiocommunication.

Those engaged in the electrical engineering profession will be puzzled to know why the electrical engineering industry, which is one of Britain's largest exporters, has been omitted in favour of one of its constituent parts. The difficulties arising from this separation show very clearly when Wilson deals with capital equipment as distinct from radio and television receivers.

Burn's 'Retrospect' deals with the criteria for judging and encouraging the efficiency of an industry. He contrasts the pre-war violent cyclic growth with the steady post-war development accompanied by creeping inflation, which tends to make a structure look more efficient. The difficulties of finding a real measure of productivity and of making comparisons internationally are clearly indicated. The section on the State as owner, supervisor, buyer and subsidizer is particularly interesting because it considers questions such as 'Why should capital be invested at the gilt-edged rate in State industry if it can be invested in private industry with a normal expectation of earnings equal to more than double the gilt-edged rate?'

Since the symposium is, in effect, a digest for the busy industrialist and journalist (and, surely, politician), it is surprising that access to the information has not been made easier by the use of charts to illustrate the structure of each industry.

C. C. CARR
ELECTRIC MACHINERY

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 537 PP. £3 14S.

IN his preface, the author states no fewer than five times that this book is a co-ordination, clarification, unification and coherent exposition of the subject of electrical machines. The text, however, does not give much evidence of these admirable qualities, unless 'co-ordination' is taken to describe the fact that every machine is called a dynamo. A typical discussion of the relations between a generator and a motor (p. 118) is anything but coherent: it reads more like a legal document.

The book is specifically for students, perhaps even more specifically for the author's own students (for he is Head of the Department of Electrical Engineering at the Pratt Institute, Brooklyn). The standard is markedly lower than would be expected of a final-year student in any British university or major technical college.

The subject coverage is almost complete, from transformers and 3-phase machines to single-phase and d.c. machines. The treatment is mainly descriptive, with very little analysis, and the scope is such as to impose in some cases a rather restricted discussion. Thus the Schrage motor gets only 34 lines. There is scarcely a reference to transient conditions and none to dynamics.

The standard of scholarship is modest, the text is flat-footed, and occasional illiteracies occur. Some of the methods used are fantastic. The ampere-turn summation for a magnetic circuit is given in terms of B/μ, and the determination of the slip frequency in the rotor of an induction motor is a cumbrous thing involving speed in r.p.m. and multiplications and divisions by 120 and the number of poles, all to get the simple answer *sf*. In a commendable attempt to aid the reader, formulae are quoted in M.K.S. and 'English' units; but the English system is not self-consistent.

Some chapters have a selection of problems, and there is a total of rather more than 300. Many of them are trivial and one or two incoherent. Altogether, the book does not measure up to the aims of its preface. The typography and the illustrations are of excellent workmanship, as can be confidently expected of the publisher.

C. F. CARTER AND B. R. WILLIAMS
INVESTMENT IN INNOVATION

OXFORD. 1958. 167 PP. 15S.

A SCIENCE and Industry Committee was appointed by the Royal Society of Arts, the British Association, and the Nuffield Foundation to investigate factors influencing the rate of adoption of new scientific and technical ideas by British industry. The first report on these matters, 'Industry and technical progress', was published in 1957 and reviewed in the *Journal* for October 1957, p. 538. The present book studies the background to investment decisions in new technical and scientific ideas.

There has been some theorizing about investment decisions —much of it little related to reality. Now a somewhat depressing picture is revealed. The authors believe that there is an unreasonably high proportion of unconsidered projects in the United Kingdom—owing to poor organization of research and development, which, it is considered, is insufficient in private industry, and to a shortage of trained men and women. In the mid-1950's many decisions were made on the stimulus of excess demand and thus fall into the class of decision for which the reasons are 'obvious'. For these latter reasons, and also because many firms lack the statistical and accounting ability required for making good estimates, most of the investment decisions studied were found to be taken without explicit consideration of yield.

The authors give an interesting list of conditions which would strengthen the willingness to invest in innovation, including: more research and development, and with much more effective direction; increased scientific literacy; and improved communication of ideas. The book will interest many electrical engineers because it indicates some of the existing difficulties in getting an idea into production and the problems that can arise in selling modern equipment to industrial concerns.

W. M. ELSASSER
THE PHYSICAL FOUNDATION OF BIOLOGY

LONDON: PERGAMON PRESS. 1958. 219 PP. 30S.

THE essence of a good argument is a controversial subject discussed by the 'intelligent inquirer' rather than the 'acknowledged expert'. To an electrical engineer who enjoys a little argumentative relaxation, this work can be recommended. One can hardly wish for a more fruitful source of controversy. Throughout the ages, philosophers have compared and contrasted living matter and inert material and have come to various conclusions on their relationship. Prof. Elsasser comes armed with a knowledge of modern physics, feedback and control and computing circuits, and information theory, ready to take on all comers in expounding his views on biology.

It is too early yet to expect an authoritative exposition of the physical foundation of biology, but many people have been thinking about this subject in the light of modern developments in other sciences, and here is an author who has put his ideas on paper. If one does not agree with everything he says, that will hardly be surprising; but he has no lack of ideas, and he gets in some telling points from time to time.

The fertilization of one field of study by the importation of ideas developed in other scientific fields often helps us in our understanding of fundamental problems, and this may be a case in point. In spite of the fact that the book deals with some difficult questions, it is easy to read and gives food for thought.

A. FEINSTEIN

FOUNDATIONS OF INFORMATION THEORY

McGRAW-HILL. 1958. 137 PP. £2 10S. 6D.

ONE wonders again, reading this book, whether the theory of the communication of 'information' through physical channels should be called 'communication theory' rather than 'information theory'. For not only was Shannon's original paper called 'A mathematical theory of *communication*', but also over 80% of Feinstein's book is concerned with the communication capacity of channels. His use of 'channel', incidentally, differs from the British Standard definition in that the latter defines it as a means of one-way communication (implicitly a means which has an indefinitely continuing existence), whereas Feinstein uses it as something of finite duration in time, i.e. as a means of communicating one out of a specified set of messages.

The first two chapters are concerned with establishing the usefulness of the function '$H(p_1, \ldots, p_n) = -c\Sigma p_i \ln p_i$,' after which the capacities of various types of channel are derived in terms of $H(X)$ and $H(X) - H(X|Y)$. The channels may be discrete or continuous, with or without memory, and include such special cases as the binary symmetric channel and the binary erasure channel. The theory is admittedly mathematical, and hence its foundations consist of a number of theorems which are proved by going through appropriate sequences of lemmas.

All this is rather tedious to the non-mathematician; but it is none the less important to have established firmly not only the theorems of upper bound of the channel capacity which is consistent with negligible error and minimum length of sequence for a given error risk, but also that the capacity of a channel cannot be increased by any process of linear or non-linear transformation (data-processing and decision processes) at the receiving end.

It is always difficult to construct simple examples to illustrate statistical theorems, but the example given on p. 26 of a noisy channel with zero equivocation is particularly unsatisfying. It is intuitively obvious that in any physical embodiment the noise could be eliminated by an appropriate system of connections at the receiving end; or, in terms of the formal statement given on p. 32, it loses no information because all the conditional probability distributions are concentrated on mutually disjoint sets. It is also a pity that the index is so slight, but on the other hand there is a useful set of references to published theoretical work up to 1958.

This book can be recommended to communication engineers who are willing to make the mathematical effort needed to verify the soundness of the foundations of their subject.

W. J. GIBBS

CONFORMAL TRANSFORMATIONS IN ELECTRICAL ENGINEERING

CHAPMAN AND HALL. 1958. 219 PP. £2 5S.

THOSE who are nervous of approaching new mathematical techniques should take comfort from the fact that this book is written by an engineer for engineers. The philosophy behind the engineering use of conformal transformations is the same as that of changing the variable in an integration in order to obtain a form which is already known. The conformal transformation operates on complex variables, therefore on two components simultaneously, and can hence be used on two-dimensional field problems.

In this book the three chapters following the introduction are devoted to a discussion of the two-dimensional Laplace field and the orthogonality of families of curves. Chapter 5 explains the transformation in terms of functions which have obvious analytic transforms, and chapter 6 introduces the Schwarz–Christoffel transformation for polygons. Chapters 7, 8 and 9 respectively apply this to configurations with 0, 1 and 2 right-angles, the last including a detailed examination of Carter's coefficient for flux fringing. Chapter 10 reveals that configurations with more than two right-angles involve elliptic integrals, and the remainder of the book from chapter 11 onwards (nearly half) is concerned with elliptic functions and their applications to this work.

The work is throughout carefully and clearly explained, and no engineer need be afraid that he will be unable to follow the mathematics. The difficulty in practice is to pick the appropriate transformation for dispositions not covered by the Schwarz–Christoffel rule. The author advises working with a table of integrals so as to avoid wasting time on performing integrations. This advice, which will no doubt be welcomed by engineers, whether or not it is approved by mathematicians, is in line with the policy of presenting the rules of conformal transformation as engineering tools rather than mathematical theorems.

One criticism is that, although the student is led very gently through the subject, he is not always told in advance where he is going. One would prefer to have an outline of the logical structure of the whole process rather than, for example, break off abruptly from the study of the transformation of configurations with more than two right-angles when it becomes apparent that elliptic integrals must be mastered before this particular type of transformation can be carried out.

The examples appear at first sight to be mainly concerned with distributions of magnetic flux in electrical machines, but they include also the electric field of a capacitor and a problem of current flow between electrodes. If the reader has problems in a different context, he should be able to apply the principles to them after mastering the contents of this book.

A. F. GIBSON, P. AIGRAIN AND R. E. BURGESS
(Editors)

PROGRESS IN SEMICONDUCTORS. VOL. 3

LONDON: HEYWOOD. 1958. 210 PP. £2 15S.

THE seven articles in Vol. 3 maintain the high standard set in previous volumes.

There is a concise but thorough account by M. Glicksman of the elucidation of the band structure of germanium and silicon from magnetoresistance, including cyclotron

resonance, measurements. Then J. M. Wilson, in discussing the chemistry of silicon and germanium, shows how laboratory methods of preparation and purification are extended to commercial processes. He also considers the evaluation of the resulting material.

There is an article by D. E. Mason and D. F. Taylor on silicon junction diodes which deals with the theory as well as the manufacture of these devices. M. S. Sodha, starting from elementary considerations, discusses the effect of the various scattering processes on the mobility of charge carriers in germanium. A. Many and R. Bray show how the lifetime of excess carriers in a semiconductor is limited by the different recombination processes.

There are two contributions, both described as interim reports, on semiconductor compounds. J. W. Mitchell discusses in detail the work on alkali halides with which he is closely associated. Finally, J. Lambe and C. C. Klick consider the properties of cadmium sulphide, which has become such an important photoconductive material.

All the articles will be of great value to those engaged in semiconductor research who wish to keep abreast of all aspects of the subject. The price is reasonable for such a well edited and produced volume, though a specialist who is interested in, say, one or two of the articles may not be prepared to buy the book. It is a pity that such useful articles are not available separately.

J. BARTON HOAG (*Editor*)

NUCLEAR REACTOR EXPERIMENTS

VAN NOSTRAND. 1958. 480 pp. £2 11s.

IT is certain that this book is one of the first to present a comprehensive cross-section of the experiments available to the student of reactor physics and technology.

Of the 49 experiments listed, three-quarters are concerned with the physics of reactors, and, except for the absence of fine-structure experiments associated with the core lattice, are typical of those performed to aid the optimizing and design of full-sized operating reactors.

The experiments include work on subcritical assemblies having all forms of moderator, and on the characteristics of the heavy-water-moderated pile, CP5. Also covered in some detail are experiments concerned with fuel metallurgy, heat-transfer media, isotope separation, and refining processes.

The theoretical treatment prefacing the experiments is, of necessity, sparse and over-simplified. It makes no attempt to interpret experimental results in the light of the generalized diffusion theory given, or to suggest corrections which would improve experimental accuracy. The important subject of health physics, instead of in a separate chapter, is dealt with chiefly by scattered references.

Almost without exception, the success of the experiments depends on the selection and use of particle counters. The chapter on nuclear-radiation detectors is complete, including details of calibration, the associated electronic circuits, and the technique of using detectors appropriate to the energy range of reactor assemblies.

Intended for the student, the book will also serve the needs of reactor engineers, though one criticizes the mass of instructional detail given, a fault of so many laboratory manuals. The format is pleasing, containing many photographs and references. It is a relief to find graphs which one can read accurately and nuclear data which are in agreement with those used in current design work.

V. G. HOLZBOCK

AUTOMATIC CONTROL: PRINCIPLES AND PRACTICE

NEW YORK: REINHOLD. LONDON: CHAPMAN AND HALL. 1958. 252 pp. £3

AS an introduction to automatic-control techniques this book achieves its aim. Written in an entirely non-mathematical way, it provides information on basic principles; and as it covers both application and derivation of the techniques it will be of value to both student and practising engineer.

American terminology, used throughout, is fully explained in the initial chapter. American and British Standard terminologies differ somewhat, but this slight handicap is, unfortunately, an ever-present difficulty in the control field. The second chapter deals with the static characteristics of control systems and briefly relates several of the common non-linearities, such as hysteresis and dead zones.

Step functions and frequency response, as applied to determining the dynamic characteristics of processes, are examined in detail. The author gives a well tried empirical method of adjusting industrial-controller settings for best results. The usual stability criteria of Nyquist and the gain and phase margins are discussed without recourse to mathematics.

Six chapters explain the equipment used in measurement and control systems. The final two chapters mention more-advanced control systems. Several applications of automatic control are well described.

Regrettably, very few references are quoted, and no indications are given of possible sources of advanced or specialized information. The book is well produced and illustrated.

H. G. HOUGHTON (*Editor*)

ATMOSPHERIC EXPLORATIONS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 125 pp. £2 12s.

CONTAINED in this book are five papers given at a symposium of the American Academy of Arts and Sciences celebrating the 250th anniversary of the birth of Benjamin Franklin. The first part, comprising three papers, concerns atmospheric electricity; and the remaining papers relate to the upper atmosphere. Together they form a striking testimony to Franklin's pioneering genius and the width of his scientific vision.

The papers are by experts in the respective fields and include descriptions of important new experimental work being done in the United States, in particular by the use of the giant cloud chamber at the Weather Bureau. The first part of the book is of great value in giving an insight into modern views on spark discharges and the electrification of raindrops and their relation to the mechanism of lightning strokes and the formation of electric charges in thunderstorms.

The second part, not unnaturally, is not so closely related to Franklin's work; though the 'meteorologist who looks at the upper atmosphere', in discussing the vertical movement of storm clouds, regards it as an extension of the work on horizontal movements initiated so long ago by 'the earliest of American meteorologists'. The last paper, on 'Phenomena of radio scattering in the ionosphere', is alone in making no reference to Franklin; and although it is a straightforward and lucid description of this new field of research, the reader may be left with the feeling that its inclusion in the symposium

was somewhat arbitrary and that a similar treatment of tropospheric scattering might have fitted more easily into the series.

The papers reveal that the explanations of many of the phenomena discussed are tentative, but they provide much food for thought, particularly for the non-specialist reader.

G. V. LAGO AND D. L. WAIDELICH

TRANSIENTS IN ELECTRICAL CIRCUITS

NEW YORK: RONALD PRESS. 1958. 393 PP. £3

AN introduction to the problem of transients in electrical circuits with linear elements is given in this work. The authors have written for a wide class of students: from undergraduates to more senior students approaching the problem of transients for the first time.

The first four chapters cover the classical method of circuit analysis, starting with circuits with one linear element and proceeding to more complicated circuits containing two 'storage' elements (i.e. inductances or capacitances) in a variety of combinations. In chapter 5 the Laplace transform is introduced and used to solve the linear differential equations of the earlier chapters (there is a short table of the more elementary transforms). Chapter 6 is concerned with a problem following on the use of the Laplace transform—that of finding the zeros of algebraic polynomials. This describes the excellent method devised by Lin besides the well-known method of Horner. This is a useful chapter, especially for the beginner.

Chapter 7 discusses circuits with mutual inductance between two coils. In chapter 8 the all-important case of circuits with sinusoidal current sources is considered; both steady-state and transient responses are dealt with in a useful unified introduction to this problem. Chapters 9, 10 and 11 extend the previous ideas to transients and steady-state solutions resulting from a variety of waveshapes.

Chapter 12 is interesting in showing that the techniques developed in previous chapters can be applied to a variety of other problems, in particular those of mechanical systems. In chapter 13 there is an introduction to the problems of circuit analysis arising from control systems, regulators and servomechanisms.

The last three chapters contain an introduction to Fourier series and integrals, together with applications to transients in electrical circuits. It is shown that some circuit problems are more readily solved by Fourier integrals than, say, Laplace transforms. The appendix contains a short table of Fourier integrals and a more extended table of Laplace transforms to supplement that given in chapter 5.

The book is an excellent introduction to circuit analysis. The reader is taken through at a steady pace, and careful explanation is offered at the more difficult stages. The emphasis on numerical solution of particular problems is most valuable, and there is a large and varied collection of examples by which the reader may assess his understanding of the text.

There are a few minor criticisms. A more detailed explanation of the theorems of Thévenin and Norton should be given. The authors should make it clear that the circuit elements must be linear for their methods to work and that the problems arising from the presence of non-linear elements are much more recondite. In chapter 6 they should point out that polynomials with real coefficients have either real roots or pairs of conjugate complex roots.

The printing is excellent.

T. J. MORGAN

TELECOMMUNICATION ECONOMICS

MACDONALD. 1958. 452 PP. £2 10S.

THE telecommunication engineer will occasionally design a new equipment in a way which he knows to be logical in approach and technically sound, only to discover that it cannot be adopted because of what appear to him to be vitiating considerations. These might be: compatibility of old and new apparatus in exchanges, utilization of existing plant, the cost of scrapping old equipment, the difficulty of introducing new maintenance techniques, and many more.

These factors represent normal currency for the engineer-economist who reduces everything to pounds sterling, and in the course of his analysis and assessment as part of an economic study, he will give due weight to such items as depreciation, life of plant equipment, planning and forecasting of future requirements, and equipment replacement, not to mention capital recovery, all of which call for the expertise of the trained telephone engineer. This the author has succeeded in conveying in his eminently readable book, which has been compiled from a fund of experience with an abundance of examples, based on British Post Office studies of multi-exchange areas, building costs, equipment needs, and line-plant provision for a telephone system.

The concept of 'present value of annual charges' has been introduced as the basis of comparison of costs between telecommunication-network schemes whose development is financed at intervals determined by anticipated traffic demands. The reader will, however, be left to wonder at the implications of currency depreciation where projects are planned for completion in say two bites at an interval of several years, and the effect on conclusions which are based on fixed present-day costs.

Errors in the text are very few and not such as to be misleading, except perhaps in the two instances where reference has been made to a leading manufacturer of exchange equipment by initial letters which are both inadequate and inappropriate.

W. T. O'DEA

THE SOCIAL HISTORY OF LIGHTING

LONDON: ROUTLEDGE AND KEGAN PAUL. 1958. 254 PP. £2 2S.

IN one volume of modest proportions, the author of this informative treatise on lighting through the ages has endeavoured to compress material sufficient for several volumes of the present size. The book spans the entire age of mankind from the earliest times to the most recent and presents to the reader a vast assemblage of facts grouped into chapters, each of which is devoted to some specific aspect of artificial lighting.

The resources tapped by the author are too numerous to be listed in detail in a book of this size, and this fact, though self-evident, is to be regretted. The work clearly reflects the result of research extending over many years, and the problem of what to omit must have constituted a major issue. Inevitably, the necessity to achieve a compromise between material and space has in places resulted in a staccato style which does not make for easy reading. It is possible that to the same factor may be attributed the paragraphs composed of somewhat disconnected short sentences which occur in the book, of which those relating to Argand on p. 49, dynamo-electric

machines on p. 128, and the decoration of lamps on p. 147 are examples.

The amount of general information given on the history of lighting is unbelievably extensive, but unfortunately the reader is hampered by an inadequate general index. One has every sympathy with the author in this respect; but the fact remains that a number of names occur in the book and are quoted in the index, yet others of apparently equal standing are not indexed. Another defect of the index, and one which is positively irritating, is that some references to a specific individual are recorded and others are not.

The author warns his readers that 'in order that each chapter may be substantially self-contained, a small amount of repetition has been unavoidable'; in fact, the amount of repetition is considerable.

Those unfamiliar with electrical history may experience difficulty in interpreting the author's remarks as he intends. Thus, on p. 57, Davy's experiments with the electric arc lamp are referred to, but it is not made clear that the light from the carbon arc was first produced by Davy in 1801, and whenever he wished thereafter. The date of 1810 quoted (given as 1809 on p. 208) is thus hardly significant.

Again, the eulogistic references to Edison on p. 23 and repeated on pp. 58 and 118 relate to 1882–83 and ignore the pioneer central stations promoted by another American, C. F. Brush, from 1879 onwards.

Nearer home, the work of the Englishman, Henry Wilde, on the marine searchlight, which dates from 1870, might have been deemed worthy of mention. However, these are all minor criticisms of a book which is both well produced and most adequately illustrated.

C. S. SISKIND

INDUCTION MOTORS—SINGLE-PHASE AND POLYPHASE

McGRAW-HILL. 1958. 390 PP. £2 18s.

THE approach in this book is basically practical, although the author is Associate Professor of Electrical Engineering at Purdue University. He thinks that the induction motor deserves complete and specialized treatment, 'in contrast to the sketchy presentation usually given in texts that deal with the general aspects of rotating machines.' The book is intended for service engineers, armature winders, self-study students of electricity, graduate engineers who wish to extend their knowledge of electrical machines, and electrical men in general who are concerned with the installation, operation and testing of electric motors.

The first two chapters deal with single- and polyphase motor principles; three others with starting, control and braking; and one with characteristics and application. The remaining six chapters are about windings. Windings are, in fact, the author's chief concern. Rewinding and reconnecting induction motors for various speeds, supplies, network voltages and frequencies are a game as much a 'craze' with Americans as baseball, it would seem; and here the game is played at length and with enthusiasm. The rules are given, and the run of play is described with a devoted fervour. And in case the reader has missed one of the finer gambits, each chapter is rounded off with 30 or 40 numbered paragraphs stating the facts in sequence. There is even a short list of sound films of interest in the field of motor application.

Large and h.v. induction motors have no special attention. The photographic illustrations, which are good and informative, all refer to machines of modest size. One picture shows a girl winding a small split-phase motor, her smile suggesting that she, too, is a devotee.

It is not easy to write a book of this kind. The absence of a co-ordinated basic theory gives the occasional formula an *ad hoc* air, and the descriptions of principles rather seem to fail because they stem from no common parentage. Empirical formulae are thrown in here and there with the justification that they give 'better results', numerical values because they are 'reasonable', methods because they 'improve performance'. Other results of the approach are the rather naïve description of the flux in a shaded-pole machine, and the artless diagram of the flux distribution in a core. Some difficulties are evaded, such as how the Schrage motor works and why a single-phase motor can run with a single primary winding. The author may run his readers into trouble with the frequently reiterated statement (made, like a good deal of the book, with a fine flush of italics) that 'the rotor *must* rotate at a speed that is *always less* than the synchronous speed'.

This book is not for the professional engineer, who may (with some justification) consider much of it trivial; but in fairness it must be noted that the author is not writing for him. The typography and diagrams have the publisher's usual standard of excellence.

A. K. SUSSKIND (*Editor*)

NOTES ON ANALOG–DIGITAL CONVERSION TECHNIQUES

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 372 PP. £4

IN automatic-control systems which employ digital information-processing the analogue–digital convertor is an important feature. This book, which is based on a special course given at the Massachusetts Institute of Technology, deals with both analogue–digital and digital–analogue convertors and provides a general theoretical background for their use.

Although there are five authors, there is a continuity throughout the book, and the reader is introduced to the techniques by a description of SAGE. This is an air-defence system with a large-scale digital computer for processing data from a network of radar stations to provide interceptor flight-path instructions.

The second chapter is concerned with the problems of using the digital information after it has been obtained from the analogue–digital convertor. The mathematical treatment here will appeal to those who have been away from formal academic work for some time, and will be helpful to students. A number of techniques which sometimes present difficulties are explained with simple but elegant pictorial demonstrations. There is a full discussion on codes, written very clearly to emphasize the principles of code design.

The main chapters of the book give a good survey of analogue–digital and digital–analogue convertors, both for the case where all the quantities are electrical and for the case when the analogue quantity is a translational or angular motion. The discussion of these convertors is primarily concerned with the principles on which they are based, but there is also a useful chapter giving practical information concerning optical convertors.

While engineers specializing in convertors will find this book of interest, they will probably be well acquainted with most of the topics. It will be of great value to students and to engineers working on these systems but not directly concerned with convertors.

*Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

AMOS, S. W., and BIRKINSHAW, D. C. 621.397

Television Engineering. Principles and Practice. Vol. 4—General Circuit Techniques*

London, Iliffe, 1958. pp. 268. 22 × 14cm. 35s.

This is the final volume of a comprehensive work on the fundamentals of television theory and practice intended primarily for B.B.C. engineering staff. It deals with a wide range of circuit techniques, including counter circuits, frequency dividers, d.c. clamping and restoration circuits, gamma-control amplifiers, delay lines, equalizers, scanning coils, field and line output stages, and shunt-regulated cathode-followers.

BECK, A. H. W. 621.385

Space-Charge Waves and Slow Electromagnetic Waves*

London, Pergamon Press, 1958. pp. xi, 396. 22 × 14cm. £4 10s.

This book is mainly a theoretical treatment of the subject, but the special points of klystrons, travelling-wave amplifiers, backward-wave oscillators, and carcinotrons are discussed. Appendices deal with measurement, the theory of the maintenance of electron beams, and matters inappropriate to the main text. It will be reviewed in a future issue.

COTTON, H. 621.3

Electrical Principles. 2nd ed.*

London, Cleaver-Hume Press, 1958. pp. xii, 382. 19 × 13cm. 12s. 6d.

M.K.S. units only are used, and the approach is through atomic structure. The inclusion of such topics as conduction in gases, thermo-electricity and d.c. machines has made the book widely useful. This edition contains a short section on terrestrial magnetism, and some changes have been made in the chapter on chemical effects.

COTTON, H. 621.315

The Transmission and Distribution of Electrical Energy. 2nd ed.*

London, English Universities Press, 1958. pp. vi, 560. 22 × 15cm. £2 2s.

This is a new edition of a book, written for both students and practising engineers, which has been brought up to date by the adoption of the M.K.S. system of units and by modifications which take account of the high voltages now used. It covers transmission lines and cables, insulation, circuit-breakers, corona, inductive interference, over-voltage and protection.

CUNNINGHAM, W. J. 517

Introduction to Nonlinear Analysis

London, McGraw-Hill, 1958. pp. ix, 349. 24 × 16cm. £3 14s.

Deals with the basic techniques for solving non-linear differential equations having a single independent variable.

DUNGEY, J. W. 523.16

Cosmic Electrodynamics

Cambridge, Cambridge University Press, 1958. pp. ix, 183. 22 × 15cm. 32s. 6d.

This book is an attempt to consolidate the theoretical foundations of the subject. It deals with electromagnetic phenomena in the sun; magnetic storms and auroral, stellar and interstellar fields; the acceleration of cosmic-ray particles; and problems of the ionosphere. It will be reviewed in a future issue.

FREEMAN, J. J. 621.396.8

Principles of Noise*

London, Chapman and Hall, 1958. pp. x, 299. 24 × 15cm. £3 14s.

This work is not concerned with acoustic noise. Introductory chapters on Fourier series and integrals, probability and stationary random processes are followed by a review of the sources of circuit noise and its measurement.

GIBSON, A. F., AIGRAIN, P., and BURGESS, R. E.

Progress in Semiconductors. Vol. 3* 621.315.59

London, Heywood, 1958. pp. vii, 210. 25 × 16cm. £2 15s.

This is the third annual volume in the series. It includes papers on the magnetoresistivity of scattering processes and the chemical purification of germanium and silicon, and on silicon junction diodes. It is reviewed on p. 679.

HAMILTON, J. J. 621.396.615

Reflex Klystrons*

London, Chapman and Hall, 1958. pp. xi, 260. 23 × 15cm. £2 5s.

This book is intended to give a grasp of the essentials of reflex klystrons. The simple theoretical treatment is amplified by descriptions of physical processes occurring in actual valves. Materials and manufacturing processes are discussed. This book will be reviewed in a future issue.

HAMMOND, R. 621.311.21

Water Power Engineering and Some Electrical Problems*

London, Heywood, 1958. pp. xiv, 302. 22 × 14cm. £2 10s.

This is a descriptive book with many illustrations of schemes, plant and equipment. The subject is considered under the following headings: the water-power industry, water-turbine design, electrical problems, hydro-electric development and tidal power.

LANSDELL, N. 621.039

The Atom and the Energy Revolution*

Harmondsworth, Penguin, 1958. pp. ix, 200. 18 × 11cm. 2s. 6d.

A book for the general reader which discusses the world demand for energy and existing fuel reserves and considers wind and water power, solar radiation and less familiar sources of energy. Atomic energy is dealt with in detail, from the fission process and the materials required to its application.

LEWIN, L. 517

Dilogarithms and Associated Functions*

London, Macdonald, 1958. pp. xvi, 353. 22 × 15cm. £3 5s.

Dilogarithms, the inverse-tangent integral and the other higher-order functions dealt with in this book have recently emerged as valuable aids in the solution of complex problems in the field of electronics. The book not only discusses these functions but also includes useful tables and a comprehensive bibliography.

McDONALD, D. 621.314.2

Power Transformers for High-Voltage Transmission*

Edinburgh, Bruce Peebles, 1958. pp. 95. 22 × 14.

A reproduction in book form of a paper read in 1957 before joint meetings of The Institution of Engineers, Australia, and The Institution of Electrical Engineers. It defines the ideal design and deals with the use of computers for design calculations covering a wide range of variables.

MONK, S. G. 621.3 (076)

Classified Examples in Electrical Engineering. Vol. 1—Ordinary National Certificate. 8th ed.

London, Pitman, 1958. pp. x, 147. 19 × 13cm. 15s.

A series of questions arranged under such varied subject headings as supply lines, resistances in parallel, magnetic fields, magnetic circuits, hysteresis, electrochemistry and heating. The answers are given at the end of the book.

NELKON, M. 537

The Principles of Technical Electricity*

London, Blackie, 1958. pp. 250. 22 × 14cm. 15s.

Covers the syllabus of the City and Guilds of London Institute examination in Telecommunication Principles I and II. Examples for the student to work are given at the end of each chapter, with answers at the end of the book.

OBURGER, W. 621.315.6

Die Isolierstoffe der Elektrotechnik (Insulating materials in electrotechnology)

Vienna, Springer, 1957. pp. vii, 542. 25 × 17cm. DM.112

Discusses the behaviour of insulating materials, giving electrical, thermal and mechanical characteristics and chemical behaviour. Both natural and artificial materials, e.g. celluloid and plastics, are described. Consideration is given to insulating lacquer and materials for insulating windings. Standards and tests are dealt with. Much of the information is in tabular form, and there is a bibliography.

PEDOE, D. 51

The Gentle Art of Mathematics

London, English Universities Press, 1958. pp. 143. 22 × 14cm. 15s.

This book describes some of the peculiarities of numbers. It presents some entertaining aspects of mathematics, concerned with choice and chance, symbolic logic, topology, permutations, rational numbers, and decimal and magical numbers.

RIORDAN, J. 512

An Introduction to Combinatorial Analysis

London, Chapman and Hall, 1958. pp. x, 244. 24 × 15cm. £3 8s.

The contents of this book include permutations and combinations, generating functions, the principle of inclusion and exclusion, cyclic representation of permutation, partitions, compositions, trees and networks, and permutation with restricted position.

SEELY, S. 538.1

Introduction to Electromagnetic Fields*

London, McGraw-Hill, 1958. pp. xi, 308. 24 × 16cm. £3 6s.

In this book it is assumed that the reader is familiar with the calculus and the important concepts of classical mechanics. The subject-matter is presented in order of increasing complexity of field concepts under the following headings: current-flow fields, static electric fields, static magnetic fields, dynamic fields, Maxwell's equations and electromagnetic phenomena. Examples of practical applications are given, and there are problems to be solved with each chapter.

SISKIND, C. S. 621.313.3

Induction Motors. Single-Phase and Polyphase*

London, McGraw-Hill, 1958. pp. ix, 390. 24 × 16cm. £2 18s.

This book discusses in detail and with a minimum of mathematics the principles, standards of operation, applications, control and design of single-phase and polyphase induction motors. It is reviewed on p. 682.

SPENCER, K. J. 534.85

High Fidelity: A Bibliography of Sound Reproduction

London, Iota Services, 1958. pp. 325. 22 × 14. 30s.

Contains 2600 references to books, articles and trade literature on the subject, published up to June 1957.

SPREADBURY, F. G. 629.135

Electricity in Aircraft*

London, Constable, 1958. pp. ix, 342. 22 × 14cm. £2

This book, of intermediate level, deals mainly with equipment since 1945. It describes generators, rotary convertors and inverters, storage batteries, switchgear and cables, and motors. There is a chapter on equipment for providing special facilities such as de-icing, jet-engine ignition, powered controls and food heating. It will be reviewed in a future issue.

TIMBIE, W. H. (revised by F. J. Ricker) 537

Basic Electricity for Communications. 2nd ed.

London, Chapman and Hall, 1958. pp. vi, 538. 22 × 14cm. £2 10s.

This is an elementary practical treatment of the fundamental principles of electricity.

TRUXAL, J. G. (Editor) 621–52

Control Engineers' Handbook. Servomechanisms, Regulators, and Automatic Feedback Control Systems

London, McGraw-Hill, 1958. pp. xi, 1100. 24 × 16cm. £7 3s. 6d.

This is a comprehensive reference work which deals mainly with the components and circuit-elements of control systems rather than the systems themselves. These include transistors, magnetic amplifiers, thyratron amplifiers, contactors, relays, and mechanical, hydraulic and pneumatic components. To be reviewed.

TWENEY, C. F., and HUGHES, L. E. C. (Editors) 413

Chambers's Technical Dictionary. 3rd ed.

London, Chambers, 1958. pp. vi, 1028. 22 × 15cm. 35s.

A dictionary arrangement of definitions of terms of importance in pure and applied science and in all branches of engineering, construction and the manufacturing industries.

WASHTELL, C. C. H. 621.318.572

An Introduction to Radiation Counters and Detectors*

London, Newnes, 1958. pp. xii, 115. 22 × 14cm. 21s.

This introduction to the subject deals with Geiger–Müller tubes, detectors based on ion collection, and other methods.

WOLFENDALE, E. (Editor) 621.314.7

The Junction Transistor and its Applications*

London, Heywood, 1958. pp. vi, 394. 25 × 16cm. £4 4s.

This volume has been prepared by a research team of engineers and physicists concerned with semiconductor devices and their applications. The first chapter gives a complete account of the physics of p-n *and* p-n-p *structure; the remaining chapters deal with the design of circuits. A review of this work will appear in a future issue.*

OTHER PUBLICATIONS

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Third Biennial A.I.E.E. Conference on Electric Heating. Papers presented at the A.I.E.E. Conference on Electric Heating, Toledo, Ohio, April 23–24, 1957

New York, A.I.E.E., 1957. pp. 126. 28 × 22cm. $3.50

Conference on Magnetism and Magnetic Materials. Papers presented at the Conference on Magnetism and Magnetic Materials, Boston, Mass., October 16–18, 1956

New York, A.I.E.E., 1957. pp. 681. 28 × 21·5cm. $7.50

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 1st November 1958

ELECTIONS

Associate Members

CLARK, Robert Malcolm
CROPPER, Henry
DELAHUNTY, Anthony Stephen, B.SC.
GLOVER, Roland Ernest, B.SC.(ENG.)
HAYWARD, John, B.E.
HUMPHREYS, Robert
INMAN, Herbert
KING, Maj. Miles Peter, B.SC.(ENG.)
LEWIS, Capt. Roger Curzon, D.S.O., O.B.E., R.N.
MOATE, George Frederick
MURGATROYD, Walter, M.A., PH.D.
POINTS, Phillip Thomas
ROBERTSON, Frederick Claude
STEARMAN, Geoffrey Hubert, B.SC.(ENG.)
STODART, Cmdr. John Campbell, R.N.
VAN DER HEYDEN, Bernardus Franciscus
WALKER, George Brown, M.A., PH.D.
WEAVER, Leslie Ernest, B.SC.
WICKINS, Jeffery
YOUNG, Alexander Macnab

Associate

FERRIS, Leslie Harold

TRANSFERS

Associate Member to Member

ARAS, Ramchandra Gopal, B.SC.TECH.
DOUBLE, Hugh Stanley, M.SC.(ENG.)
FLETCHER, Frank Leonard, B.SC.(ENG.)
GREEN, Sam
HOLMES, John Hardy, B.SC.(ENG.)
JEFFERSON, Col. John Carnt
McCLEERY, James Alexander
MITCHELL, John, B.SC.(ENG.)
MORRISON, Ronald James
PAUL, John Michell
PILLAI, Kannusamy Thiagaraja, B.A.
ROBERTSON, James Cameron
SIMONS, Evelyn John
SOWERBY, James McGregor, B.A.
THOMAS, Graham Isaac, B.SC.
TWEEDDALE, Leonard, M.SC.TECH.
WADDY, John Coulson
WINTON, Robert Charles, B.SC.
YOULE, Frederick, B.SC.(ENG.)
YOUNG, Leo, M.A., M.S.

Associate to Member

SMALL, Andrew James Don, B.SC.

Graduate to Associate Member

ADDISON, John, B.SC.(ENG.)
AIREY, Francis Herbert
ALLEN, Nigel Robert
ARNISON, Gordon Harrison
BALDWIN, John Beverley, B.SC.
BARKS, Donald Tinsley
BARRETT, Frederick
BENNETT, Charles Roy, B.SC.TECH.
BIRTWISTLE, Brian, B.SC.
BLANCHARD, Donald Thomas
BOLTON, George Vincent Richard
BRIGGS, Alan Charles, B.SC.(ENG.)
BUTLER, William Eric, B.ENG.
CAMPBELL, Alexander Gordon
CASSWELL, Peter Henry
CHEN, Shou Lum, M.SC.(ENG.)
CHILD, Peter John Channing, B.SC.(ENG.)
CLARKE, Derek Versey
COMAR, Donald Victor
CONIBEAR, David Eustace, B.SC.(ENG.)
COULTER, Eric
DAVIS, Alfred James
FIELDWICK, Robert John
FOURNIER, William Elliott
GORRY, Walter Leopold
GREENER, Derrick
GRIFFITHS, Charles Joseph
HADLEY, Douglas Tony
HALL, Charles Leefe
HALL, Geoffrey
HALL, Peter
HALLIDAY, Dixon Brydson, B.SC.
HARDING, William Henry
JONES, Desmond Hector, B.E.
KEARNS, Frederick Denis
KOSTKA, Marek Edward, B.SC.(ENG.)
LEWIS, David Glyndwr
LONG, Robert Douglas
McCULLAGH, Raymond Fenton, B.E.
McNEILL, Peter Calwell, PH.D., B.SC.
MASON, James Paton, B.SC.
MATTHEWS, Stanley Ernest
MORGAN, Keith, M.SC.(ENG.).
MOTHERSOLE, Peter Leonard
MURPHY, William
NEALE, Frank William
NICOL, James Somerville
NUTTALL, Thomas William Brooke, B.SC.
PARSONS, Peter Isaac James, B.SC.
PEAKALL, Eric Douglas
PEARSON, John
PENVER, Arthur William
PITTS, David
POWELL, John Edward, B.ENG.
ROBERTSON, James
ROSSIDES, Panayiotis Christodoulou, B.SC.
RUTLEDGE, Peter Donald
SIMPSON, Christopher Paul, B.SC.
SMITH, John Brian
SMITH, Patrick, B.SC.(ENG.)
SNELLING, Michael Antony, B.SC.(ENG.)
STACEY, Robert Sidney
STAVROPOULOS, Christo Costa, B.SC.(ENG.)
STEWART, Kenneth Gordon, B.E.
SWEENEY, Patrick Alexander, B.E., B.SC.
TAVENER, Leonard Charles
TAYLOR, Cyril
THOMS, Dennis Arthur William, B.SC.(ENG.)
TRIM, Richard Morris
TRUBSHAW, Geoffrey Edward, B.SC.(ENG.)
TURNER, Francis William
WALKER, Bruce Forbes, B.SC.
WALTON, Alfred Peter
WATSON, Felix Veeraratnam Vernon, B.SC., B.SC.(ENG.)
WEBSTER, Bernard Raymond, B.SC.(ENG.)
WILKINS, Raymond John, B.SC.(ENG.)

Graduate to Associate Member (contd.)

WINSPER, Henry
WOOD, Ivan James
WOOLWAY, Alfred Geoffrey
WRIGHT, John Eric

Student to Associate Member

WRAGGE, Harry Stewart, B.E.E., M.ENG.

Student to Associate

GRAHAM, Ninian Wilson

The following elections and transfers approved by the Council are effective from the 6th November 1958

ELECTIONS

Graduates

ASPINALL, Leslie
BALDWIN, Desmond Stanley Frederick
BINGHAM, Alan William Bernard
BRIGHT-DAVIES, Alexander Lankwei
BURGESS, Norman
BURROWS, Bernard Albert
CLEMENTS, John McFadyen, B.E.E.
DAVIES, Gareth John
DRISCOLL, Peter
FINDLAY, Alexander James
GODFREY, Michael Russell, B.SC.(ENG.)
HAMPSON, Robert Percy
HARDING, William John
HEMMS, Brian
HENSLEY, George
LAMB, Richard
MARTIN, Peter Brian
MORGAN, George
OVER, Kenneth Charles
PRITCHARD, Thomas Joseph
RECKLESS, Edward Richard
SCOTT, Alexander William
SIMMERS, James Manson, B.E.
SMITH, Colin Breakspear
SPRIGGS, Alan Sidney Percival
STOCKLER, George
SUVANAPIMPA, Sommai, B.SC.
THOMAS, Douglas
TOMKINSON, Thomas Alfred
WALKER, Peter
WATTS, Peter McDonald
WELBOURNE, Daniel, B.A.
WILLIAMS, George Spark
WRIGHT, Ronald William
YEATES, William Frederick John
ZAFIRIS, John Athanasios, B.SC.(ENG.)

Students

ASHDOWN, Michael Bryan
BAKER, Patrick Frederick
BARKER, Duncan John William
BARKER, Norman Stuart, B.SC.
BELSHAM, Derek John
BINDING, Norman Hedley
BROWN, Frank Walter Edward
CHAPMAN, Robert Lancelot
CHATFIELD, David John
COLLENDER, Gordon Ernest, B.SC.
CRAGGS, Peter Arnold
DUCK, George William, B.SC.
EVANS, Alan
FAIRLIE, Joseph Wilson, B.SC.
GERRY, Raymond William
HARRISON, Terence Philip
HODGE, Anthony Alva, B.SC.
HODGES, John Michael
HUNTER, William Alexander
HYDE, David Blake
JESTY, Richard
JEWSON, David Winn
KENNEDY, Matthew Campbell, B.SC.
LAPIDOS, Abraham
LINCOLN, Raymond William
MEIR, Peter Frederick
MOAT, Alistair Cooper
MORGAN, Keith William
NORTON, William Maurice
OKEKE, Benson Alpha Chukwuka
PATTINSON, Ian Raine
RAILTON, Peter Lawrence
REED, Keith
REED, Robert Charles George
ROHATGI, Naveen, B.SC.
SHORT, Peter John
SOUTEN, Keith Henry
STEELE, Dennis Edward
SYMONS, Frederick John Walter
TOMASINA, Ronald John Peter
WALTON, Roy William
WATSON, Gerald John
WEBBING, Frederick John
WHALLEY, Geoffrey
WHITFIELD, Neville Stuart
WILKS, Ernest Robert

TRANSFERS

Student to Graduate

ALTY, John Anthony Rixton, B.SC.TECH.
BACH, Frederick George
BECKFORD, Donald, B.SC.(ENG.)
BIGGS, Keith John
BUCKHAM, Malcolm William, B.E.
CHADDHA, Naubat Rai, B.SC.
CHRISTOPOULOS, André
CLIBBON, Michael Edward, B.SC.(ENG.)
COPPEL, Stanley John, B.SC.
DEVENISH-MEARES, Basil Leycester, B.SC.
FARMER, William Trevor James, B.SC.
GORDON, George Michael Winston, B.SC.
GREEN, Stephen, B.SC.TECH.
GREENAWAY, Hugh Thomas
HUTCHINSON, Michael Miles, B.SC.(ENG.)
JOHNSON, Eric, B.SC.(ENG.)
JUNG, Iftikhar Hamidullah
KENNETT, Douglas Bryan, B.SC.(ENG.)
KIIL, Bjarne
MABOGUNJE, Olabisi Adebayo
McCREA, Robert Eoin, B.SC.
MILLS, David, B.SC.
MOORE, Jack Arthur
ONUOHA, Emmanuel Alaoma, B.SC.(ENG.)
RAMANATHAN, Kaithakode Puthanvedu
RILEY, Paul Ian, B.SC.TECH.
SAUGEN, Jon Erik
SEARLE, David Donald, B.SC.(ENG.)
SIMPKIN, Stanley, B.SC.(ENG.)
STACEY, Colin Hubert
SYNNOTT, Edward Christopher, B.E.
THOMAS, Roy, B.SC.(ENG.)
TOWERS, Alfred Norman, B.SC.TECH.
WADE, Brian Newman, B.SC.
WILLIAMS, Thomas Arthur Kennedy, B.SC.

Elections and Transfers (continued)

The following elections and transfers approved by the Council are effective from the 1st December 1958

ELECTIONS

Associate Members

BALFOUR, Melville Wilfrid, B.SC.
BARKER, Joseph Arthur
BURR, Ronald Lawrence, B.SC.
BURTON, Hubert George
CZAJKOWSKI, Zbigniew, B.SC.(ENG.)
GALL, Frederick, B.SC.
HARTLEY, Henry Frederick
HEINRICH, Dieter Otto, DIPL.ING.
HOLDEN, Frank
MILKOWSKI, Stanislaw, B.E.
MORGALLA, Norbert Walter
NELSON, Wallace
NICHOLLS, George Henry Clifford, M.E.E.
NYE, Donald James

Associates

HEPBURN, Alexander
HOWELLS, John Raymond, B.A.
REID, Eric

Companion

DODDS, Alfred Sutherland

TRANSFERS

Associate Member to Member

BURTON, Roland Newton
CHAMPION, Capt. Bernard Harden, R.N.
GODFREY, Ronald Montague, B.SC.(ENG.)
McCARTHY, Denis Walter Charles, O.B.E., M.A.
MANSSEN, Norman Bernard, B.E.
MITSON, Arthur Stephen, O.B.E.

Associate Member to Member (contd.)

PATEL, Kantilal Chaturbhai
REEKIE, James, B.SC., PH.D.
REEVES, John Mackay
SAYER, Charles Martin B.SC.

Graduate to Associate Member

ARCUS, Geoffrey William, B.SC.(ENG.
ATKINSON, Robert Vincent
BARBER, John Anstey, B.SC.
BARRY, Edgar Thomas
BARTLETT, Gordon Albert, B.SC.(ENG.)
BECKEY, Alan John Waller
BELL, Ronald Robert
BLANK, Hans Gert, B.SC.(ENG.)
BOOTH, John Halswell, B.SC.(ENG.)
BOWEN, William Gerald
BOWES, Robert Colin, B.SC.
BROWN, Harold Stanley
BUSFIELD, Clifford Arthur
DALE, Stanley George
DAWSON, John McLean
EDWARDS, Dion Arthur Raymond
FEDO, John Frederick
FERGUSON, Colin Frederick, B.SC.(ENG.)
FILER, Paul Janes
GARDNER, Reginald John
GARLAND, Kelvin David, B.E.
GIBSON, Thomas
GRANGE, Colin Roy, B.SC.(ENG.)
HALSEY, John Roddick, B.SC.(ENG.)
HARRIS, Frederick Ralph
HAZELL, Dennis William Reginald
HEALD, Wyndham Haldane, B.SC.
HOARE, Derek Thomas, B.SC.
HODGE, Brian Herbert, B.SC.
HOPE, Cyril
JACOMB, Raymond Philip
JARMAN, David Roy, B.SC.(ENG.
KAY, Sydney Pitfield, B.SC.(ENG.)
KNIGHT, Robert William, M.SC.
LATHAM, Robert Leonard Anthony
LEEK, Owen John
LISTER, Stuart Gerald
MAIN, James Redshaw
MELLERS, John, B.SC.TECH.
MURRIE, John Anderson
NASH, Peter Stanley
OMER, William John, B.SC.(ENG.)
OSWALD, Howard Rupert
PAYNE, John Michael, B.SC.(ENG.)
RIDGE, Leslie Derek, B.SC.(ENG.)
RITCHIE, Robert, B.SC.TECH.
RUSH, Derek Anthony
SALISBURY, Alexander Edward
SHEPHERD, Robin Bruce, B.SC.(ENG.)
SHUTE, Ralph Ashley
SMITH, Robert John
TIZZARD, Flt.-Lt. John, B.SC., R.A.F.
TOWERS, Christopher Joseph, B.ENG.
WALKER, Harry
WILLMOTT, Harold John Keith
WINFIELD, Alan Osborne
WOOD, Michael Richard

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (DECEMBER 1958)

L. L. ALSTON, B.SC.(ENG.), PH.D. PAPER 2723 M **High-temperature effects on flashover in air** *December 1958*

P. F. GUNNING. PAPER 2626 S, MAY 1958 **Standardization of control facilities for the British Grid: communications, indications and telemetering** *December 1958*

G. A. BURNS, F. FLETCHER, M.B.E., C. H. CHAMBERS, AND P. F. GUNNING. PAPER 2627 S, MAY 1958 **Development of communication, indication and telemetering equipment for the British Grid** *December 1958*

F. C. WINFIELD, M.ENG., T. W. WILCOX, AND G. LYON, M.SC.(ENG.). PAPER 2583 S, MARCH 1958 **Design of the 330 kV transmission system for Rhodesia** *September 1958*

J. N. PREWETT, M.A. PAPER 2602 M, APRIL 1958 **Method of measuring and displaying generator rotor angle** *July 1958*

E. B. POWELL AND M. E. HARPER. PAPER 2576 M, APRIL 1958 **Generator-rotor-angle measurement by stroboscopic means** *July 1958*

F. MORAN, M.SC. PAPER 2598 M, APRIL 1958 **Power-system phase-angle measurements** *July 1958*

E. C. ROGERS, B.SC. PAPER 2730 M **Self-extinction of gaseous discharges in cavities in dielectrics** *December 1958*

Discussion on **Mechanical strength of power transformers in service** before the East Midland Centre, the Rugby Sub-Centre, the North Staffordshire Sub-Centre, the Western Supply Group, the South-Western Sub-Centre, and the South-East Scotland Sub-Centre

Discussion on **Electrical equipment for rectifier locomotives** and **circuit calculations for rectifier locomotives and motor-coaches** before the North Midland Utilization Group, the North Staffordshire Sub-Centre, the North-Eastern Centre, the Mersey and North Wales Centre, and the South Midland Centre

Discussion on **Cathodic protection** before the Mersey and North Wales Centre, the North-Eastern Centre, the North-Western Centre, the North Staffordshire Sub-Centre, the Northern Ireland Centre, the South-Western Sub-Centre, and the Western Centre

Discussion on **Some aspects of heat-pump operation in Great Britain** before the North Midland Utilization Group

Discussion on **Supply-voltage and current variations produced by a 60-ton 3-phase electric-arc furnace** before the North-Western Centre

Communicated discussion on **Experimental approach to the cooling of transformer coils by natural convection**

Discussion on **Development of transportable thermal-storage space heaters** before the North Midland Utilization Group

PART B. RADIO AND ELECTRONIC ENGINEERING (NOVEMBER 1958)

See the Journal for November, p. 631

PART C. MONOGRAPHS (SEPTEMBER 1958)

See the Journal for September, p. 519

British Nuclear Energy Conference

DETAILS of two forthcoming meetings of the British Nuclear Energy Conference are given below. Unless otherwise stated, the following particulars hold for them: they take the form of the presentation and discussion of one or more papers; they are held at 5.30 p.m., with tea at 5 p.m.; and tickets of admission are not required.

1959

JANUARY 15 *Thursday*

Sponsoring society and place of meeting: The Institution of Electrical Engineers, Savoy Place, London W.C.2.

ELECTRICAL INSTALLATION AT CALDER HALL NUCLEAR POWER STATION
N. J. Mackay and E. Hardwick

JANUARY 22–23 *Thursday–Friday*

SYMPOSIUM ON NUCLEAR FUEL CYCLES

Sponsoring society: The Institute of Physics, 47 Belgrave Square, London S.W.1. (The Institute will announce later the place of meeting.)

Papers will be read on these subjects: Long-term reactivity, Theory of once-through fuel cycles, Perturbation due to fuel cycles, Optimization of fuel cycles for nuclear power stations, and Fuel-cycle operational problems

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH NOVEMBER 1958

	No of Contributors	£	*s.*	*d.*
£1000 and over	6	6000	0	0
£100 to <£1000	30	6586	3	0
£5 to <£100	867	9185	9	5
£2 to <£5	2084	5730	7	5
Under £2	24213	12654	13	5
		£40156	13	3

THE FARADAY LECTURE IN LONDON

THE Faraday Lecture will be delivered by Dr. H. A. Thomas, M.SC., MEMBER, at the **Royal Festival Hall,** London S.E.1, on Monday, 26th January 1959, at 6 p.m., his subject being 'Automation'.

The primary object of the Faraday Lecture is to increase the interest of the general public in electrical matters, particularly those having an immediate bearing on the life of the community; **members are therefore requested to bring the Lecture to the notice of their friends.**

Admission is free, by ticket obtainable from the Secretary; members are requested to enclose a stamped addressed envelope with their applications.

Dr. Thomas is with Unilever's Engineering Department. After a brief historical review, the Lecture covers automatic control in the process industries; the development of automatic operations in the engineering industries for making, inspecting, assembling, testing and packing; and the replacement of some of man's mental effort by machines. The last concept is destined to revolutionize our present methods of production.

The history, operation and applications of electronic computers are explained. The use of computers in decision taking is illustrated by an entirely new film specially prepared for the Lecture, and by a large working model of the automatic factory of the future.

HUNTER MEMORIAL LECTURE

THE title of the first Hunter Memorial Lecture, to be delivered by Mr. C. O. Boyse, B.SC.(ENG.), MEMBER, on the 8th January 1959, is 'P. V. Hunter—electrical engineering in our time'.

The Lecture will review the achievements of P. V. Hunter and his qualities as an electrical engineer, both in retrospect and in their impact on present-day and future developments.

1958 AMENDMENTS TO WIRING REGULATIONS

THE Wiring Regulations Committee have considered representations by interested bodies who had inquired, through the British Electrical and Allied Industries Research Association and the British Electrical Development Association, whether an appropriately designed unit could be safely used to give a supply to an electric dry-shaver, notwithstanding the requirements of Regulation 405(c), in a room containing a fixed bath. Particular importance was attached, in this regard, to the convenience of visitors from oversea, who were accustomed to a facility of this kind in hotel rooms and elsewhere. The Committee had before them a report by a special Panel which had been appointed by the Chairman to consider this question.

As a result, the Committee requested the British Standards Institution to prepare a draft British Standard for supply units for electric dry-shavers, and specified certain characteristics which they regarded as essential to safety in such units. This Standard has now been published as B.S. 3052.

The Council of The Institution have authorized the promulgation of the Thirteenth Edition of the Regulations with 1958 Amendments which become effectual on and from the 15th December 1958. The Amendments have the effect of recognizing, by means of an exemption to Regulations 405(B) and 405(C), the use in bathrooms of shaver supply units complying with B.S. 3052 and installed in conformity with the Regulations.

The Amendments also incorporate a revised Regulation 507 and Note—Test of Effectiveness of Earthing; other amendments, generally of a minor character, have been included which are referred to in the Introduction.

The Regulations with 1958 Amendments have been approved by the Minister of Power and the Secretary of State for Scotland for the purpose of the Electricity Supply Regulations, 1937.

Copies of the Thirteenth Edition with 1958 Amendments may be obtained from the Secretary, at these post-free prices: paper, 6s.; cloth, 8s. 6d. Copies of the 1958 Amendments alone are available separately for 1s. 6d. post-free and need to be read in conjunction with the text of the Thirteenth Edition (1955) of the Regulations.

WIRELESS TELEGRAPHY ACT, 1949

THE Postmaster General made, on the 12th November 1958, an announcement in these terms:

'I hereby appoint, in accordance with section 9, sub-section (2), of the Wireless Telegraphy Act, 1949, Mr. P. A. T. Bevan, B.SC., M.I.E.E., to be a member of the Advisory Committee on Interference from Ignition Systems.'

RETIRED MEMBERS AND THOSE OF LONG STANDING

MEMBERS are reminded of a rule which has been in existence for some years and which enables Corporate Members and Associates who have retired from the profession and are still desirous of retaining their membership of The Institution to do so without payment of further subscriptions. It is left to the members concerned to make application to be brought within the rule. The rule, which does not apply retrospectively, is as follows:

Any Corporate Member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council to waive his future annual subscriptions provided that his membership of The Institution has been continuous for at least 25 years. If he desires to continue to receive the *Journal* he can do so on payment of 10s. per annum. Parts A, B and C of the

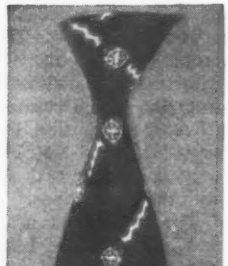
Proceedings will also be available to him at the appropriate subscription rates.

In addition to the foregoing, it should be noted that a further rule provides that as soon as a member of any class has completed 50 years of membership he will not be required to pay any further membership subscriptions, regardless of whether he is still in remunerative employment. This rule operates automatically, and the member on qualifying is notified accordingly. If he desires to receive the *Journal* or the *Proceedings*, the arrangement for retired members of 25 years' standing also applies.

THE INSTITUTION TIE

SUPPLIES of the tie, and of a square (30 × 30 in.) of the same design, can be obtained on application to the Secretary. The charges are as follows:

Ties:	
silk (heavy quality)	£1 3s. 6d.
Terylene–silk	£1 1s. 0d.
rayon–silk	15s. 0d.
Squares:	
silk	£2 12s. 6d.
rayon–silk	£1 15s. 0d.



The general appearance of the tie may be seen from the accompanying illustration. A wavy gold line, edged in red, running diagonally across the navy-blue background of the tie, represents wave motion, one of the fundamental concepts of electrical engineering which appear on The Institution's coat of arms. A shield of light blue—by common consent the predominantly 'electrical' colour—shows a winged golden thunderbolt enclosed in a golden ring bearing golden fleurs-de-lis at the four cardinal points. This alludes to the power of electricity circumscribed and under control; the fleurs-de-lis on the encircling ring make a passing reference to the compass card and thus to our seal and to the work of Kelvin.

STUDENTS' QUARTERLY JOURNAL

THERE is a pleasing variety of subject-matter in the articles in the December 1958 issue of the *Students' Quarterly Journal*. Electric power development in New Zealand is discussed by J. M. Dykes, B.E.; J. Cudworth has an article on a 3 h.p. synchronous motor; R. G. Morris, B.SC., considers meteor-burst scatter communication; standardization and simplification of switchgear is the subject of M. J. L. Willison's contribution; while D. W. Martin surveys the use of electricity in agriculture.

An account of printed circuits and automatic assembly, by J. B. Lavery, B.SC.(ENG.); shorter notes on the construction of graphs and charts and on the performance and design of a.c. commutator motors; and announcements, Section news and book reviews are included in this issue.

As from the 1st January 1959, the annual subscription for members of The Institution other than Graduates and Students is 8s. 6d.; single copies cost 2s. 6d. each.

PRACTICAL PAPERS IN THE *PROCEEDINGS*

THE Council welcome the submission, for publication in the *Proceedings*, of short papers dealing with practical problems encountered in the development, manufacture, operation or maintenance of electrical equipment. Such papers are useful to other members facing similar problems. They may be quite short, of any length between, say, 750 and 2500 words. A short practical paper has an obvious attraction for the engineer who is too busy to prepare a full-length one, and it provides information in a form which readers can usually assimilate rapidly. It is hoped that more members will write them than at present.

SUBSCRIPTIONS TO THE PUBLICATIONS OF OTHER ENGINEERING INSTITUTIONS

WE remind members of the reciprocal arrangements whereby they can obtain the technical periodicals of other engineering institutions and societies at the specially reduced rates listed below:

	£ s. d.
Institution of Civil Engineers:	
Proceedings (Single issues, 3s. 6d.)	2 0 0
Institution of Mechanical Engineers:	
Chartered Mechanical Engineer	1 18 9
Chartered Mechanical Engineer and separates of *Proceedings* and Automobile Division *Proceedings*	7 3 9
Chartered Mechanical Engineer and separates and bound volumes of *Proceedings* and Automobile Division *Proceedings*	10 2 6
Chartered Mechanical Engineer and bound volumes of *Proceedings* and Automobile Division *Proceedings*	8 16 3
Bound volumes only of Institution *Proceedings* and Automobile Division *Proceedings*	7 5 0
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Electrical Engineering	2 10 0
Transactions	4 0 0
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L'Elettrotecnica	2 18 0
Alta Frequenza	2 2 0
Dansk Ingeniørforening:	
Ingeniøren	1 5 0
Engineering Institute of Canada:	
The Engineering Journal	1 9 0

Institution of Engineers, India:			
Journal			
Part I (civil and general section)	1	7	0
Part II (mechanical, electrical and general section)	1	7	0
Both the above parts..	2	14	0
Single copies		2	3
Institute of Physics:			
British Journal of Applied Physics	3	0	0
Journal of Scientific Instruments	3	0	0
Both the above publications	6	0	0
Institute of Radio Engineers, America:			
Proceedings	4	17	6
Transactions of the 21 Professional Groups ..	35	16	6
Transactions of any single Professional Group	3	1	0
Institution of Engineers, Australia:			
Journal	3	3	0
Koninklijk Instituut van Ingenieurs:			
De Ingenieur	2	5	0
New Zealand Institution of Engineers:			
New Zealand Engineering		14	6
Société Belge des Électriciens:			
Bulletin	1	7	6
Société Française des Électriciens:			
Bulletin	3	15	0
South African Institute of Electrical Engineers:			
Transactions	2	1	0
Svenska Teknologföreningen:			
Teknisk Tidskrift	4	0	0
Verband Deutscher Elektrotechniker e.V.:			
Elektrotechnische Zeitschrift edition A (*ETZ-A*)	3	15	0
Elektrotechnische Zeitschrift edition B (*ETZ-B*)	1	17	6
Elektrotechnische Zeitschrift editions A and B	5	2	6
Nachrichtentechnische Zeitschrift (*NTZ*) ..	2	14	0

Members' subscriptions must be transmitted through the Secretary of The Institution of Electrical Engineers, except those for the publications of The Institution of Mechanical Engineers, which should be sent to the Secretary of that Institution, and those for the *Proceedings* of The Institution of Civil Engineers, which should be sent to one of the following agents:

Sir Isaac Pitman and Sons Ltd.: The Book Centre, North Circular Road, Neasden, London N.W.10; Little Collins Street, Melbourne, Australia; Pitman House, 381–3 Church Street, Toronto, Canada; 27 Becketts Buildings, President Street, Johannesburg, South Africa; Pitman Publishing Corporation, 2 West 45th Street, New York; A. H. Wheeler and Co., Hornby Road, Bombay; 11 Clive Street, Calcutta; and 115 Elgin Road, Allahabad.

WHITWORTH FOUNDATION AWARDS

THE new arrangements for the Whitworth Foundation Awards were related in the *Journal* for July 1955, p. 490.

The Minister of Education offers for competition in 1959 these awards:

(1) Whitworth Fellowships, up to three, normally tenable for two years. The value will be £500 a year and may be supplemented by dependants' allowances and travelling allowances.

(2) Whitworth Prizes, up to six, of £50 each, to unsuccessful competitors whose work deserves recognition, to be spent on furthering the competitors' engineering education in a manner approved by the Minister.

To be eligible for an award a candidate must be a British subject; be of sound bodily constitution and of good character; and not have previously held a Fellowship or a Senior Whitworth Scholarship. He must have either an engineering qualification of university-degree standard approved by the Minister, or a Higher National Diploma or Higher National Certificate in engineering with at least two distinctions. He must also have received organized, progressive practical training in engineering in one or not more than three continuous periods totalling 104 weeks. Drawing-office experience may be included up to a maximum of six months.

Each candidate must submit a 2000–4000-word thesis on a subject approved beforehand by the Ministry. A candidate may be required to sit a short examination on the basic principles of engineering and to appear for an interview before the examining body.

Applications should be made on the prescribed form not later than the 14th January 1959. Inquiries and requests for application forms should be made to the Secretary, Ministry of Education [F.E. 1(c)], Curzon Street, London W.1. Theses must be sent to the Ministry between the 1st March and 1st April 1959.

Full details of the awards are given in 'Rules and conditions for the award of Whitworth Fellowships and Prizes', obtainable for 3d. (by post 5d.) from H.M. Stationery Office, York House, Kingsway, London W.C.2, or through any bookseller.

CORROSION SCIENCE

1959 ESSAY AWARD

THE Education Panel of the Corrosion Group of the Society of Chemical Industry offer a prize of the value of 25 guineas for an essay or paper on any aspect of the corrosion of metals and its prevention.

Entries, from persons aged not more than 27 years on the closing date, the 31st March 1959, should be of about 4000 words and be addressed to the Corrosion Group Essay Competition, c/o Society of Chemical Industry, 14 Belgrave Square, London S.W.1.

THE INSTITUTION OF ENGINEERS (INDIA)

THE 39th annual session of the Institution of Engineers (India) will be held at Madras between the 30th January and 2nd February 1959. The session will conclude with study tours of engineering projects in Madras State. Members who may be in India at that time are invited to take part in the session.

MILLIMETRE WAVES

AN international symposium on millimetre waves will be held from the 31st March to 2nd April 1959 in the auditorium of the Engineering Societies Building, 33 West 39 Street, New York City, N.Y., U.S.A. Sponsors of the symposium are the Polytechnic Institute of Brooklyn, the Department of Defense Research Agencies, and the Institute of Radio Engineers.

BULLETIN OF THE SECTIONS

RADIO AND TELECOMMUNICATION

The Chairman's message : Functions of sub-committees

MY concluding remarks in the November *Bulletin of the Sections* referred to the purpose of the Section Committee in serving the interests of the members as a whole, and I wish here to mention its structure and the organization of its work by the various sub-committees. By the Section Regulations the committee must have at least two, but not more than three, Vice-Chairmen, and so far it has been the custom to have only two. This year, with the increasing scope of the Section's activities, especially with the sponsoring of symposia and conventions, the committee have exercised their right, and Mr. M. J. L. Pulling, now in his second year of office, is joined by Mr. T. B. D. Terroni and Mr. R. J. Halsey.

We intend to give short biographical sketches of some of the members of the committee, so that here it will suffice to mention that, in addition to *ex-officio* members, including the President, the Chairman of the Papers Committee and a Council representative, there are at present 15 ordinary members, together with non-voting representatives of the local Radio and Telecommunication Groups and of the Royal Navy, Army and Royal Air Force.

The basic work of the committee is done by a number of sub-committees, the detailed functions of which will be described subsequently; but the three main ones are the Advisory, Papers and Programme, and Social Sub-Committees. The relationship of the Advisory Sub-Committee to the Section Committee is similar to that existing between the General Purposes Committee and the Council. As the name implies, it advises on matters of policy and procedure covering the whole field of interest of the Section.

The Papers and Programme Sub-Committee is responsible for the sponsoring of papers for publication and reading and for the planning of the programme of the Section meetings throughout the session. It has obviously a very important duty in obtaining papers and speakers for the symposia and conventions and in implementing the new division of our meetings into those of general interest and those on specialist topics.

The Social Sub-Committee has an equally important part to play in organizing the many social activities that provide opportunities for the members to get to know one another and to combine business with pleasure by visits to various organizations at home and abroad.

Between these main sub-committees there is close co-operation, as is exemplified, for instance, in planning the technical sessions and the social functions associated with a convention and in promoting an exhibition such as is being held in connection with the forthcoming International Convention on Transistors and Associated Semiconductor Devices.

Not long ago, the official duties of the Vice-Chairmen were few, as it was customary for the Chairman to take the chair at most of the main sub-committees and at all the evening meetings of the Section. In order to lighten the load on the Chairman and to give experience to the Vice-Chairmen, a system has been established over the last year or two whereby the Chairman still presides at the evening Section meetings following on the Section Committee meetings in the afternoon, while the other meetings are shared out among the Vice-Chairmen, who also take the chair at meetings of the major sub-committees.

Ending on a personal note, this shouldering of part of the Chairman's formal duties by the Vice-Chairmen will leave me free to accept invitations to visit Local Groups. I have already had the pleasure of two such visits, which I am sure will help to strengthen the ties between the Section Committee and their counterparts in the Local Centres. G. MILLINGTON

A thumbnail sketch

MR. G. MILLINGTON first joined The Institution as an Associate Member in 1946, becoming a Member in 1950. After serving on the Radio and Telecommunication Section Committee from 1951–54, he was elected a Vice-Chairman in 1956, and this year he is Chairman of the Section.

He was born in Southwark, London, in 1904 and was educated at St. Olave's Grammar School and Clare College, Cambridge. After taking Part II of the natural sciences tripos in physics in 1926, he did two years' research at the Cavendish Laboratory on the passage of β-particles through thin foils, followed by two years on acoustical research at the Columbia Graphophone Co. His work on the measurement of absorption coefficients led to a modified formula for reverberation which has been widely used in the testing of recording studios.

G. Millington, Chairman of the Radio and Telecommunication Section

In 1931 he joined Marconi's Wireless Telegraph Co. and specialized, under T. L. Eckersley and K. W. Tremellen, on radio-wave propagation. In 1953 he became chief of the propagation section, having meanwhile built up a mathematical group to serve the research laboratories as a whole.

Since the recent war he has been to many international conferences, including the Atlantic City Radio Conference of the International Telecommunications Union and all the assemblies of the C.C.I.R., in which he is the vice-chairman of the study group on ground-wave propagation.

He has also attended many of the assemblies of the Union Radio Scientifique Internationale and serves in a personal capacity on several radio committees of the D.S.I.R. He has written many scientific papers and was awarded the Duddell Premium of The Institution in 1949.

Summer Visit to Taplow Court

TAPLOW Court, Buckinghamshire, the Thames-side home of British Telecommunications Research (B.T.R.) Ltd., provided an attractive venue for the Section's Summer Visit on the 19th July.

B.T.R. is jointly sponsored by British Insulated Callender's Cables Ltd. and the Automatic Telephone and Electric Co. Ltd., and a wide range of equipment designed and manufactured by the group was on display. The exhibits were accommodated in a marquee, which blended most happily with the background of the historic house and riverside estate, enhanced by a rare day of unbroken sunshine.

Sir Archibald Gill, Chairman of B.T.R. Ltd., and Lady Gill were hosts. Sir Archibald welcomed the visitors at lunch and Dr. J. S. McPetrie, Chairman of the Section, replied. Through Sir Archibald's long association with the Post Office Engineering Department and as a Past-Chairman of the Section, the guests included many personal friends, a circumstance which did much to encourage the cordial informality which characterized the Summer Visit.

The activities of the B.I.C.C./A.T.E. group cover the whole field of cable and communication engineering, and more than 300 items were displayed. Prominence was given to the revolutionary changes in engineering techniques brought about by the advent of reliable transistors and printed circuits, which, occurring simultaneously with the development of new materials for insulation, have stimulated research into the possibility of providing a complete transmission system at a circuit cost substantially lower than attainable hitherto.

A component of such a system which aroused considerable interest was a buried repeater accommodated in a relatively shallow space beneath a man-hole cover, powered by a d.c. supply from the terminal station via the transmission cable. Conventional power transformers, smoothing circuits, and the necessity for providing a fool-proof personnel-protection scheme, all of which are required for equipment using thermionic valves, are eliminated, and special arrangements for thermal dissipation are unnecessary.

Equally impressive were the many ingenious adaptations of the magnetic drum, both in their application for high-speed switching on telephone networks and as memory stores.

Members of the party at tea in the grounds of Taplow Court

One exhibit employing the device displayed a map on which a national dialled-telephone network was shown. Visitors were invited to simulate the condition of a principal trunk line being 'busied out' at any point between main exchanges. Lamp indicators then showed the rapidity with which the equipment rerouted the call over an alternative transmission path.

Radio equipment displayed included an experimental v.h.f. radio-telephone link operating over a 75-mile circuit, employing a repeater station which has been successfully run entirely on solar power, and virtually unattended for over 12 months.

Frequency-shift telegraph transmission and automatic tape-reading equipment was demonstrated, including apparatus which, operating over radio links, maintains an extremely high stability, enabling the frequency spectrum per channel to be narrowed to 50c/s and less. The same stand displayed a transmission-distortion-measuring set of a type which has been adopted by civil and military authorities on a world-wide basis.

Cruising down the river

Following lunch, the afternoon temperature made the cool river breezes a more than attractive prospect, and the Section guests were conveyed up-river by coach to the village of Bourne End, returning by steam launch along the finest of the upper-Thames reaches, overshadowed by the tall woods of Cliveden, through Boulters Lock and back to Taplow.

True to the pattern of the day, leave-taking was preceded by tea served on the close-cropped lawns surrounding the old house, the historic associations of which were told in the booklets presented, in which the old and the new were effectively contrasted to provide a souvenir of yet another successful Summer Visit. R. N. M.

SUPPLY

By magic carpet from London

IN London, the Supply Section is the last off the mark to commence sessional activities; nevertheless a flying start was made by the Chairman, Mr. D. P. Sayers, who took a large and appreciative audience on an excursion from the ramparts of Savoy Place to the notable features in the territory of the supply side of the industry.

Those attending its presentation, on the 29th October, were whisked, in the manner of the Arabian Nights stories, to see the development of large power stations, both thermal and nuclear, in Great Britain: to substations in the Soviet Union: to the Zambesi in flood in the Kariba Gorge. These places and elsewhere were delightfully illustrated in colour.

Mr. Sayers gave facts relating to the intake into the various branches of the electrical industry and stressed that there was still a wealth of romance and glamour (and hard work) available to those who sought to embrace the 'heavy current' side with its steady rate of progress.

Following the address, Mr. J. E. L. Robinson, Vice-Chairman, in a series of tongue-twisting alliterations, and making his own extension of the comparatives of the word 'say' and mention of soothsayers, gracefully commented on the incoming Chairman in moving the vote of thanks.

To the Immediate Past-Chairman, Prof. M. G. Say, Mr. P. J. Ryle, Past-Chairman, conveyed on behalf of the Section its appreciation. He drew attention to the demands made on the Professor in time and physical effort in maintaining his Supply Section work and his able representation on Council and other Committees, bearing in mind that he is domiciled over the Border. Dr. Forrest, Vice-Chairman, seconded the motion.

Provincial outlook

To those migrants who have enjoyed participation in the activities of the Local Centres, the healthy and often vigorous discussions which the residents conduct are well known. It is, however, not always appreciated that two Supply Groups and one combined Supply and Utilization Group have full sessional programmes, containing the 'curtain-raisers' to meetings to be held in London or extensions to the discussions already held elsewhere.

The North Western Supply Group, under the chairmanship of Mr. J. Whitfield, held a meeting on the 21st October at which a paper by Messrs. E. P. G. Thornton and D. H. Booth, 'The design and performance of the Gas-Filled cable system', had an excellent reception. On the 25th November, a paper on the 330kV transmission system for Rhodesia, by Messrs. F. C. Winfield, T. W. Wilcox and G. Lyon, received a warm welcome and, as expected, promoted considerable local interest. On the 27th January 1959 the Group will discuss control and communication problems relating to the British Grid.

The Western Supply Group commenced the session with the Chairman's Address given by Mr. A. G. Milne, who successfully tackled the ever-pressing problem of the relationship between the engineer and the community. He stressed the need for the cultural broadening of the engineer, while indicating that humanists should not neglect an appreciation of science. The programme for November and December covered the operational problems in both thermal and nuclear power stations. On the 19th January a paper on the future pattern of nuclear power stations, by Mr. I. Everson, will undoubtedly create much interest.

Already the South Midland Supply and Utilization Group, whose Chairman this session is Mr. J. R. Anderson, have had three meetings. On the 13th October, a paper dealing with colliery-winder drives was well received by a full audience. November saw the furtherance of the discussion on solid-rotor asynchronous generators. The December meeting became a multi-society gathering, being held jointly with the South Midland Centre, the local Radio and Measurement Group and the Birmingham Centre of the Institution of Post Office Electrical Engineers, to discuss the control facilities and communication problems of the power-supply side, the papers being contributed by Mr. Gunning and his collaborators. With the New Year, a new scene will be set by the presentation of a paper on h.b.c. fuse links, and it is anticipated that considerable interest will be aroused.

These brief notes merely indicate the vigour existing within the framework of the Section. Members can be assured that, on journeys taking them to Centres when activities are in progress, they will be most welcome. F. C. W.

IT is regretted that, owing to an editorial confusion of identities, it was stated in the November *Journal* on p. 632 that Mr. William Fraser, the Managing Director of Scottish Cables Ltd., had died on the 11th October 1958. The death referred to was in fact that of the Chairman of the company, Mr. William Fraser, the uncle of the gentleman referred to in the report.

NEWS from the Centres

WESTERN CENTRE

Supply problems and prospects

THE session opened in Bristol on the 13th October, when the new Chairman, Mr R. W. Steel, was inducted in the chair by the retiring Chairman, Mr. J. F. Wright. Mr. Wright, in his introductory remarks, commented on his busy but happy year of office and how successful it had been. He wished Mr. Steel a similar period of office and thanked the Committee, in particular the Honorary Secretary, Mr. F. F. Freeling, for their kind help.

Mr. Steel, in response, remarked on the diligence of Mr. Wright, which had left him with nothing to do as Vice-Chairman last year, and presented him with the certificate of chairmanship for the last session.

The Honorary Secretary announced that Mr. W. J. Pohl had been awarded a Radio and Telecommunication Section Premium and Mr. A. R. Daniels a Graduate and Student Premium. The latter Premium was presented by the Chairman. The Chairman then gave his Address, taking as his subject 'Some problems and prospects of the electricity supply industry', which he illustrated with lantern slides.

He drew freely on his long service in the supply industry

and considered the comparison between the past, present and future of the industry. Sir Hamish MacLaren proposed a vote of thanks to the Chairman and expressed his pleasure at being able to be present. There were about 100 present.

New departures this year include the holding of children's sessions for the Faraday Lecture and a children's Christmas lecture in the South-Western Sub-Centre, which we proudly announce is to be given by one of our own members, Prof. Rawcliffe, of Bristol University. There is no doubt about the success of it, and we fully anticipate that this type of lecture will become more popular.

The programme for the new session is in full swing, with a number of District Meetings arranged. Particular attention is being given to the Gloucester and Cheltenham area, which, it is felt, deserves more attention than it has so far received.

D. J. T.

NORTH MIDLAND CENTRE

Distribution in Yorkshire and Rhodesia

THE first Ordinary Meeting of the new session was held on the 7th October under the chairmanship of Mr. A. J. Coveney, who, when opening the meeting, commented on the record attendance of 175 members and visitors, saying it augured well for attendance during the coming session. He welcomed seven new Corporate Members and explained to them the aims of The Institution.

Mr. Coveney then introduced the new Chairman, Mr. J. D. Nicholson, and invited him to give his Chairman's Address, 'The use and distribution of electricity in the Y.E.B. area during 1948–58'. This proved to be a very careful analysis of the growth of demand and the development of the system used by the Yorkshire Electricity Board, accompanied by comparative statistics of performances.

In a vote of thanks, a Past-Chairman, Mr. F. K. Fleming, pointed out that it was a most appropriate subject in view of the author's personal association with the period in question. Prof. G. W. Carter, seconding the vote of thanks, admired the author's grip of multifarious details and stressed the value of the address to people not concerned with day-to-day working. The vote of thanks was carried with acclamation.

Dr. Walton made the customary appeal on behalf of the Benevolent Fund, and a hat collection produced £29 10s.

Mr. Coveney then vacated the chair and, after thanking the Committee and members for their assistance and support during his year of office, invited Mr. Nicholson to take over, with the wish that his year of office would be very successful and happy. Mr. J. D. Nicholson said that he was honoured to be elected Chairman and accepted with the knowledge that he could rely on Mr. Coveney's wise guidance. Mr. H. A. Moody, proposing a vote of thanks to the retiring Chairman for his services to the Centre, stressed his qualities of enthusiasm and interest and his genial personality.

After a suitable reply by Mr. Coveney, Mr. J. D. Nicholson presented him with a certificate of chairmanship and a copy of the 'History of The Institution' to mark his year of office. He also presented a Premium certificate to Mr. H. Myers for his Graduate and Student Section Chairman's Address. Before the meeting closed, a special appeal was made by Mr. H. S. Moody for all senior members to give the maximum support to the Graduate and Student Section activities and to encourage all Students to take an active interest in Institution affairs.

The second Ordinary Meeting was held on the 4th November with an attendance of 85 members and guests. It was opened by Mr. J. D. Nicholson, who welcomed two new Corporate Members.

The Chairman then welcomed Sir Willis Jackson, a Vice-President, saying how pleased and honoured he was that Sir Willis was able to join them, and invited him to address the meeting on a subject of his own choosing.

Sir Willis said that such visits were very pleasurable to him and afforded opportunities of meeting old friends. He then gave a brief description of the major reconstruction work to be carried out on the Institution building in London—outlining measures already carried out and plans for the future.

After thanking Sir Willis, the Chairman introduced Mr. T. W. Wilcox and Mr. G. Lyon, who, with Mr. F. C. Winfield, jointly presented a paper on 'The design of the 330kV transmission system for Rhodesia'. This was followed by an interesting discussion, to which the authors ably replied.

The Chairman, in a vote of thanks, commented on how interesting it was for engineers to be introduced to such an experience which comes to so few of us. After comparing the different kinds of difficulties experienced at home and abroad, he congratulated the authors on their free and forthright replies to the discussion. Mr. T. W. Wilcox thanked the Chairman and stressed that the complete scheme was the work of a very large team, mentioning the excellent co-operation they had received from manufacturers and the valuable support given by the client.

North Midland Utilization Group

The new session of the Utilization Group was opened on the 21st October 1958. The retiring Chairman, Mr. J. L. Browell, introduced the new Chairman, Mr. A. R. Rumfitt, and commented on the latter's long service in the Group. A Past-Chairman, Mr. R. Spence, proposed a vote of thanks to Mr. Browell, who replied by paying grateful tribute to his Committee, and in particular to the retiring Honorary Secretary, Mr. G. Auton.

Mr. F. Bentham then read his paper on 'Electrical control of stage and television lighting'. With many touches of humour drawn from his wide experience, he showed that the operator of the equipment had to be both an electrician and an artist. After a lively discussion, Mr. Rumfitt proposed a vote of thanks to the author, which Mr. Bentham suitably accepted.

W. J. W.

SCOTTISH CENTRE

Inaugurations at large

ALTHOUGH the new Centre Chairman, Mr. R. J. Rennie, had delivered his Address on 'The electricity supply industry in Scotland' at the opening meeting in Edinburgh on the 7th October (see the November *Journal*, p. 634), he was formally inaugurated as Chairman in Glasgow, the headquarters of his home Sub-Centre, on the 15th October. Mr. Rennie very graciously thanked the retiring Chairman, Mr. E. O. Taylor, and presented him not only with the customary formal parchment recording his chairmanship, but also with a more personal memento—his photograph mounted with the Scottish version of the Institution coat of arms.

On the two succeeding evenings Mr. Rennie repeated his Address in Dundee and Aberdeen; on each occasion the meeting was preceded by an inaugural dinner presided over by Mr. S. R. Urquhart, at which Mr. Rennie and the retiring

Centre Chairman were the chief guests. At the Dundee meeting Mr. Rennie's first official duty was to present the Heaviside Premium to Dr. A. J. O. Cruickshank for his two papers on the analysis of linear and non-linear circuits.

At the meeting of the South-West Scotland Sub-Centre in Glasgow on the 29th November, the retiring Chairman, Dr. A. J. Small, inaugurated the new Sub-Centre Chairman, Mr. W. Adam. The new Chairman thanked Dr. Small for the very painstaking work that he had done for the Sub-Centre and, as a memento of his year of office, presented him with a copy of the 'History of The Institution'.

After remarking that the degree of civilization in a community appears to be measured by the quantity of paper it consumes, Mr. Adam devoted his Chairman's Address to an admirable description of an electronically controlled paper mill at Guardbridge in Fife. It is noteworthy that such a remote Scottish village should be the home of the first sectional drive of this type in Europe.

In the North Scotland Sub-Centre Prof. Cullwick inaugurated the new Sub-Centre Chairman, Mr. S. R. Urquhart, at Dundee and Aberdeen on the 23rd and 24th October. For his inaugural meetings Mr. Urquhart had invited Mr. C. L. C. Allan to give an account of the work of the North of Scotland Hydro-Electric Board; this review, which discussed the development of the Board's network, the difficulties that it had to meet and the prospects for the future, was very much appreciated by those present in both cities.

Owing to the recent unexpected departure from Scotland of both Vice-Chairmen of the South-East Scotland Sub-Centre, Mr. J. Mendelson is continuing in office as Chairman for a second year; his opening meeting therefore included no special formalities. E. O. T.

NEWS from Abroad

QUEENSLAND OVERSEA COMMITTEE

Radio-interference problems

AT a meeting on the 6th August, Mr. S. G. Fraser, B.E., presented a paper on 'Advances in h.v. techniques in North America'. During the first few months of 1958 the speaker made a series of visits to several North American laboratories dealing with high-voltage research, before taking up his present position on the staff of the University of Queensland.

The most active fields of investigation were observed to be fractional-microsecond insulation co-ordination, transmission-line performance and radio-interference investigations, and Mr. Fraser gave a brief outline of work being currently carried out in these fields.

The fractional-microsecond investigations appear to be claiming most attention, owing to the gap in our present knowledge of insulation co-ordination data below one-microsecond durations. The nationally supported laboratories focus their attention on the measurement problems, and it is interesting to note that, while the National Research Council of Ottawa is actively developing a shield-compensated voltage divider, the Americans generally prefer low-impedance uncompensated units. Methods of calibrating fast-response impulse-voltage dividers were discussed, noting particularly the work of the N.R.C., as described in the 1958 C.I.G.R.É. session, in producing a chop duration of the order of 1 millimicrosec.

Some of the problems of transmission-line performance confronting those authorities considering line voltages of the order of 300 kV and above were outlined, and a description was given of some model tests carried out by one of the major electrical-equipment manufacturers in the United States.

Most of the talk centred on the problems of measuring radio interference, in which subject there is so little agreement at present. The requirements of a radio noise-meter were outlined, and the need for careful specification of r.f. bandwidth and phase shift, in addition to detection time-constants, was stressed. The differences in performance of currently available radio-interference meters were shown to be the result of a general lack of appreciation of the magnitude of the problems involved in making radio-interference measurements.

Some practical problems of radio-interference testing, such as the test circuit, use of coupling capacitors and obtaining an interference-free test environment, were discussed, and information was presented representative of several recent investigations on transmission-line conductors.

Finally, the facilities planned for the University of Queensland were outlined. A new laboratory is to be constructed to house power-frequency test equipment for 1000 kV 50 c/s, and impulse plant for 3 MV, for which finance is being provided by the Electrical Research Board of the Electricity Supply Association of Australia. The 50 c/s set is expected to be a cascade type, suitable for use as a 3-phase bank, and of a low radio-interference level to allow such tests to be made with a minimum of difficulty. It is likely that the new laboratory will be a major centre for research and special testing of extra-high-voltage equipment in Australia.

The meeting was well attended by members of the electricity supply authorities and staff of the Postmaster General's Department, who contributed in detail to the discussion on the problems of interference measurement.

The cross-Channel cable

Mr. F. J. Lane, a former member of Council, made a brief visit to Brisbane on the 18th and 19th September. The Oversea Committee arranged for him to address a meeting on the evening of the 18th September, and Mr. Lane took as his subject 'The cross-Channel cable'. He traced an investigation made and the designs prepared for an a.c. interconnection of the power systems of Great Britain and France, which proceeded to the stage where experimental cables were laid on the British side of the Channel. However, owing to the progress in the commercial application of transmission by direct current, plans were changed, and Mr. Lane detailed the reasons for this and described the plans which had been made to construct the present approved d.c. interconnection system between the two countries. W. I. G.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th October to 15th November 1958 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

BASEDEN, C. (Gironde, France)
BICKERDIKE, S. R. (Melbourne)
EMMS, A. G. (Christchurch, New Zealand)
GRIFFITHS, C. J. (Melbourne)
LIGHTBODY, E. W. (Brisbane)
LINDSELL, R. A. (Gibraltar)
MOORE, G. W. (Baghdad)
NETHERSOLE, J. (Johannesburg)
ROBINSON, R. V. (Lagos)
SEYMOUR, G. R. (Sydney)
SUDAN, R. N. (Calcutta)
SWAN, S. F. (Konongo, Ghana)
TURNER, H. A. (Sarawak)
TYRRELL, P. J. (Kuala Lumpur, Malaya)

INDEX TO THE JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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NOTE. In the index, titles of articles, papers, lectures and books are printed in italic type.

Papers and Monographs of the *Proceedings* figure in these features of the *Journal:* **A Review of the *Proceedings*, Parts A and B; Papers and Monographs published individually this month; Bulletin of the Sections; London Report;** and **Contents of the Current Issues of the *Proceedings*.** To ease reference and to save space, all these entries are brought together and listed in alphabetical order of authors' names under one combined heading: ***Proceedings* papers and monographs.** There is, however, a separate additional detailed indexing of **A Review of the *Proceedings*, Parts A and B.** Papers and Monographs of the *Proceedings* do not therefore, unlike the *Journal* articles proper, appear in the main index alphabetically under title or author. Similarly, the names of deceased members are given only under the heading **Obituary,** particulars of letters only under **Correspondence,** and details of books reviewed only under **Some Recent Books.**

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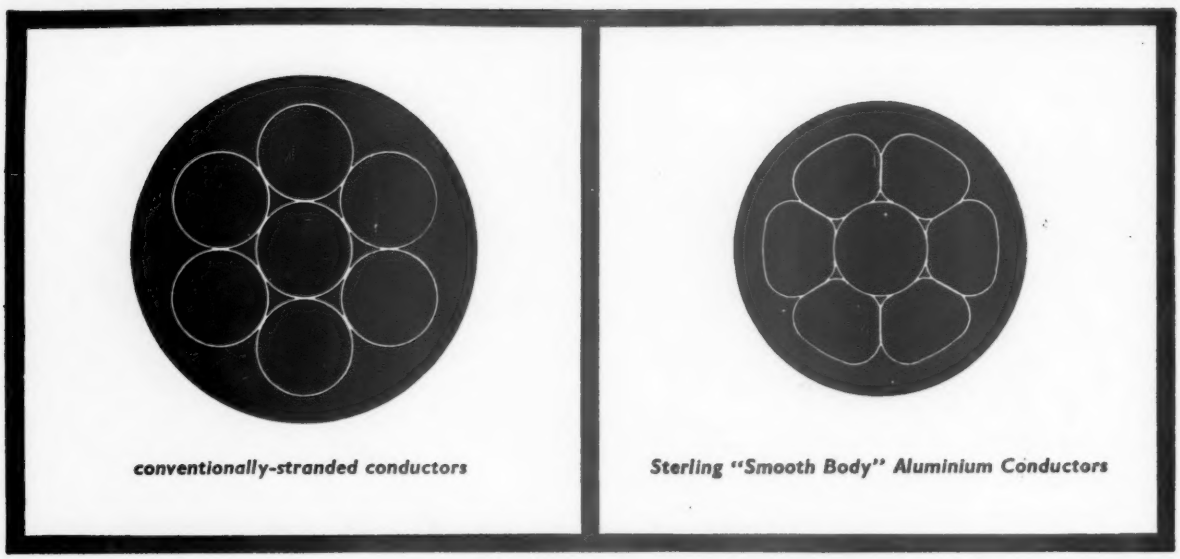

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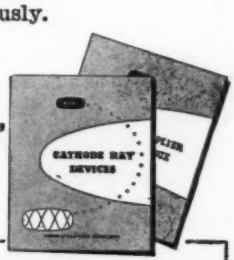

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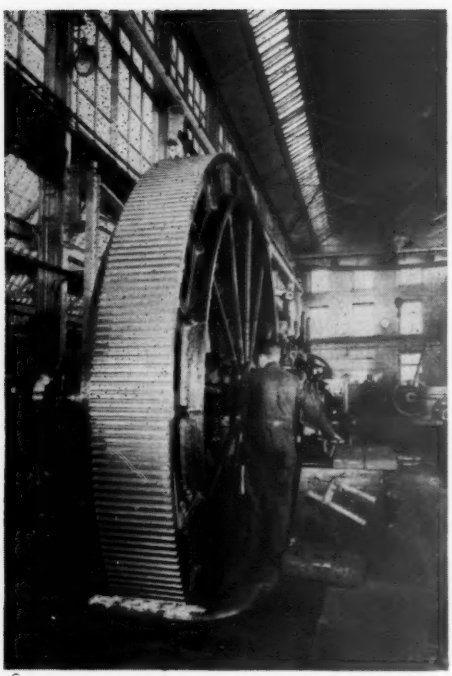

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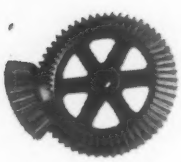

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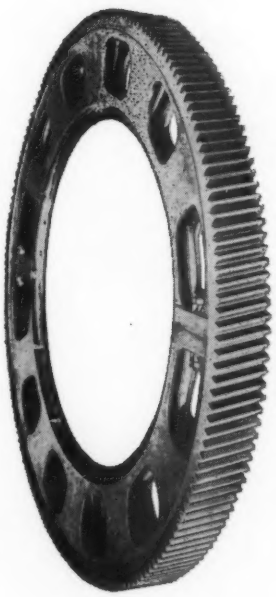

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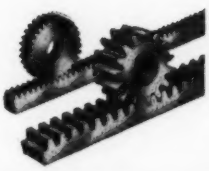

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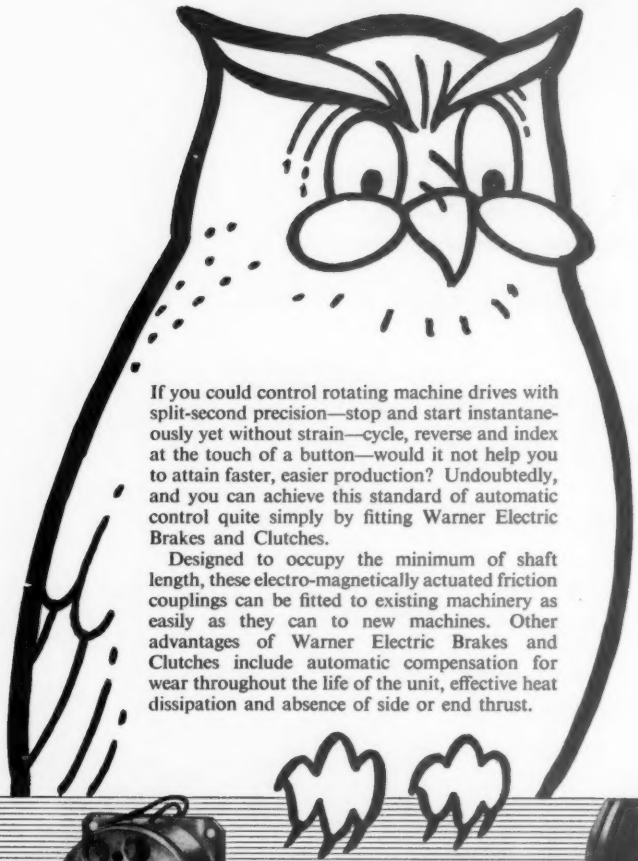

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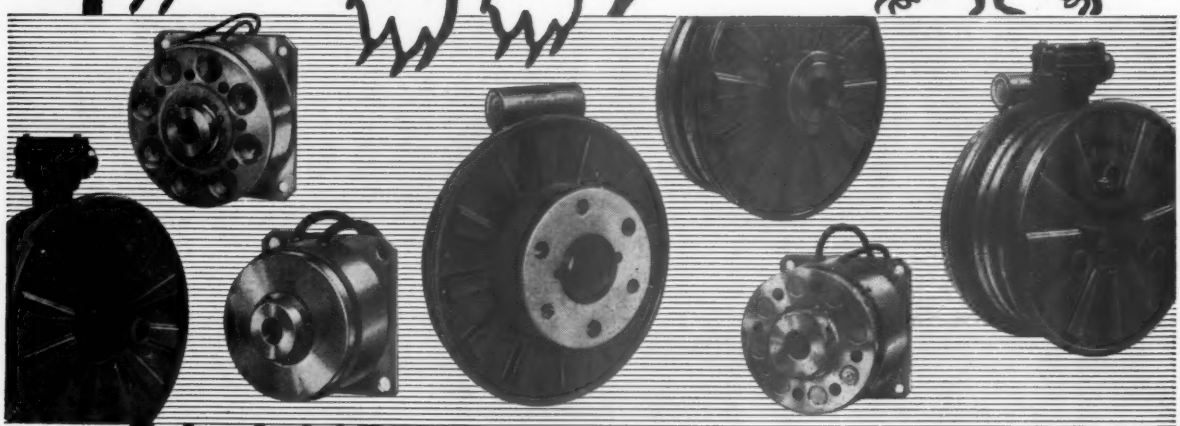

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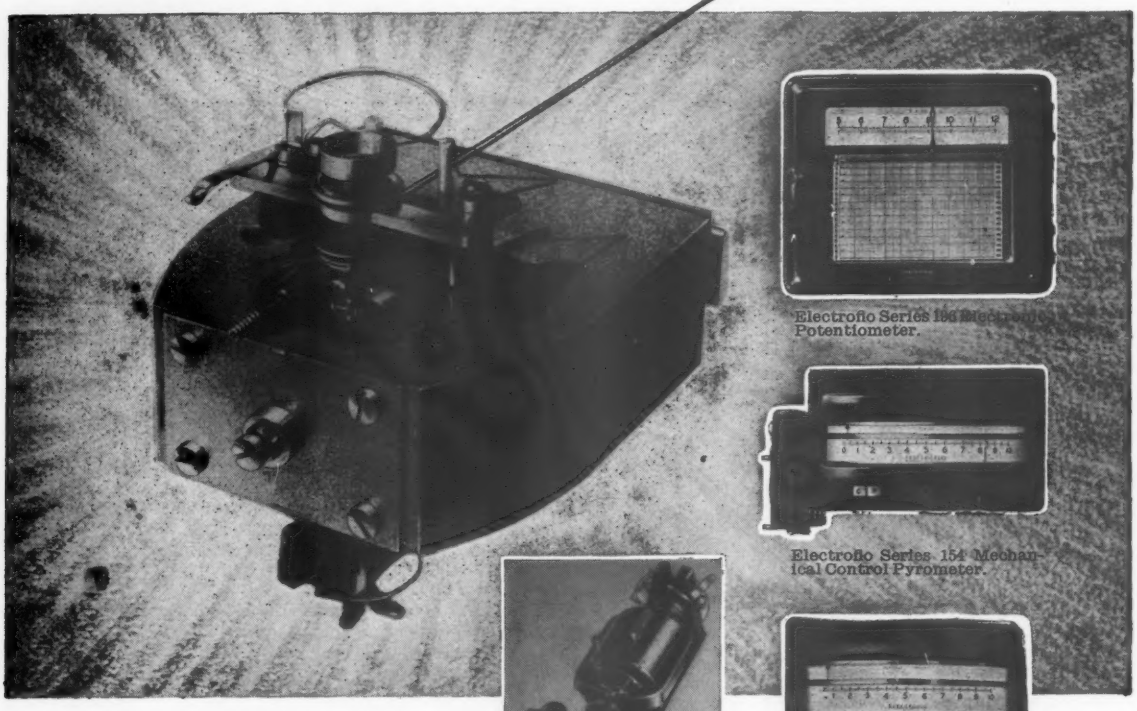

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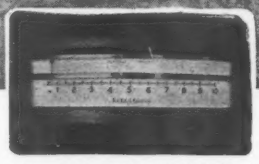

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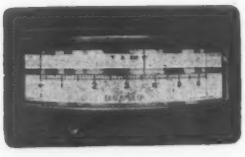

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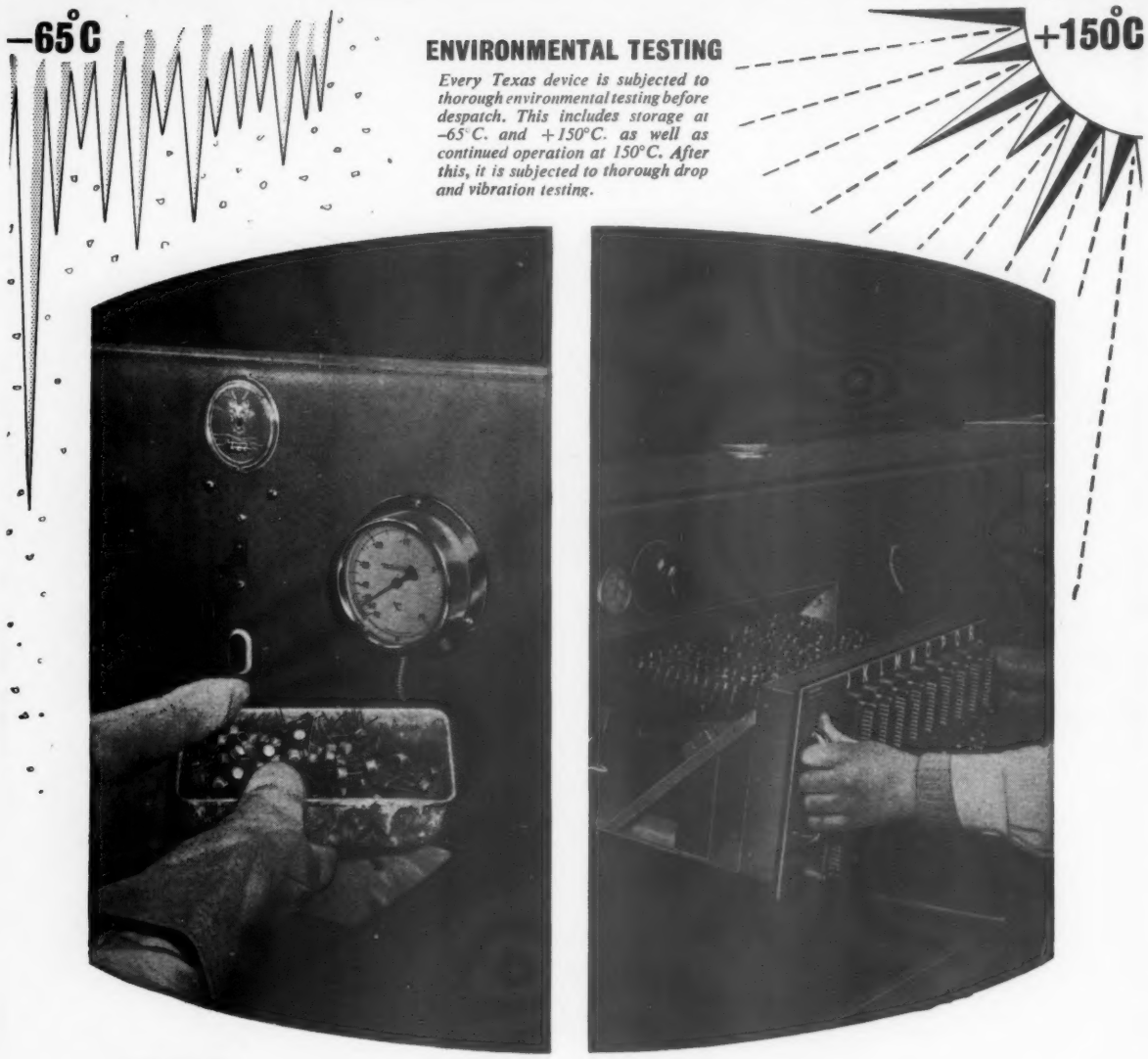

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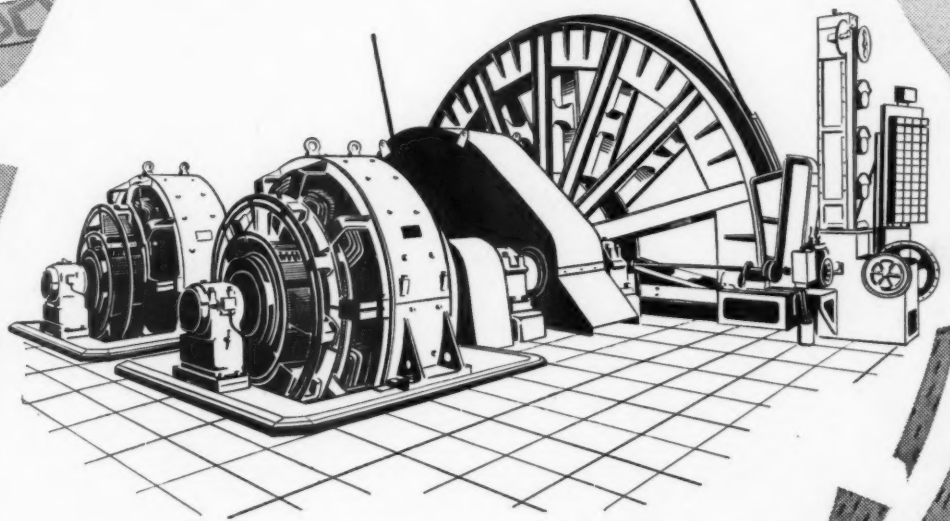

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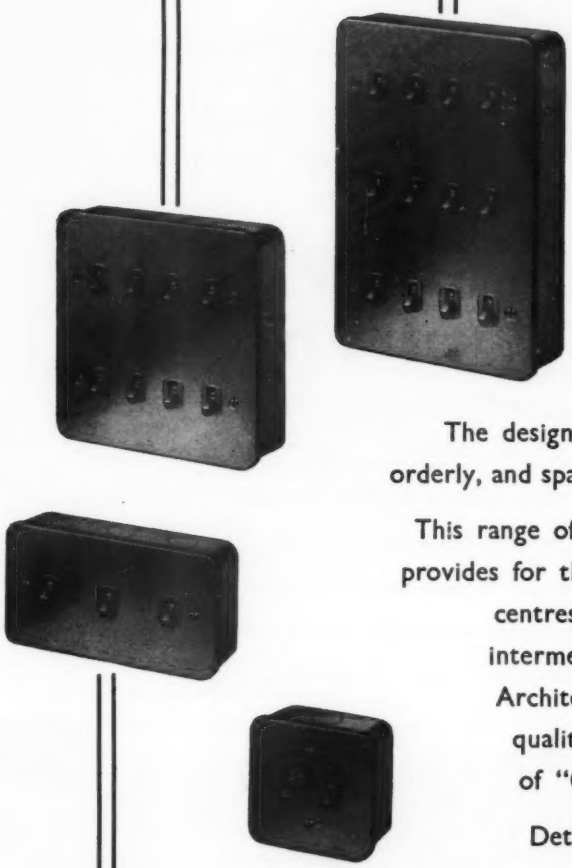
OVERSEAS REPRESENTATIVES: ARGENTINA: H. A. Roberts & Cia., S.R.L., Buenos Aires. **AUSTRALIA:** Hackbridge and Hewittic Electric Co. Ltd., 171, Fitzroy Street, St. Kilda, Victoria; N.S.W.: Queensland: W. Australia: Elder, Smith & Co. Ltd.; South Australia: Parsons & Robertson Ltd.; Tasmania: H. M. Bamford & Sons (Pty.) Ltd., Hobart. **BELGIUM & LUXEMBOURG:** Pierre Pollie, Brussels, 3. **BRAZIL:** Oscar G. Mors, Sao Paulo. **BURMA:** Neonlite Manufacturing & Trading Co. Ltd., Rangoon. **CANADA:** Hackbridge and Hewittic Electric Co. of Canada Ltd., Montreal; The Northern Electric Co. Ltd., Montreal, etc. **CEYLON:** Envee Ess Ltd., Colombo. **CHILE:** Sociedad Importadora del Pacifico Ltda., Santiago. **EAST AFRICA:** Gerald Hoe & Co., Nairobi. **EGYPT:** Giacomo Cohenca Fils, S.A.E., Cairo. **FINLAND:** Sähkö-ja Koneliike O.Y. Hermes, Helsinki. **GHANA, NIGERIA & SIERRA LEONE:** Glyndova Ltd. **GREECE:** Charilaos C. Coroneos. Athens. **INDIA:** Steam & Mining Equipment (India) Private Ltd., Calcutta; Easun Engineering Co. Ltd., Madras 1. **IRAQ:** J. P. Bahoshy Bros., Baghdad. **MALAYA, SINGAPORE & BORNEO:** Harper, Gilfillan & Co. Ltd., Kuala Lumpur. **NETHERLANDS:** J. Kater, E.I.* Ouderkerk a.d. Amstel. **NEW ZEALAND:** Richardson, McCabe & Co. Ltd., Wellington, etc. **PAKISTAN:** The Karachi Radio Co., Karachi, 3. **SOUTH AFRICA:** Arthur Trevor (Williams (Pty.) Ltd., Johannesburg, etc. **CENTRAL AFRICAN FEDERATION:** Arthur Trevor Williams (Pty.) Ltd., Salisbury. **THAILAND:** Vichien Phanich Co. Ltd., Bangkok. **TRINIDAD & TOBAGO:** Thomas Peake & Co., Port of Spain. **TURKEY:** Dr. H. Salim Öker, Ankara. **U.S.A.:** Hackbridge and Hewittic Electric Co. Ltd., P.O. Box 234, Pittsburgh 30, Pennsylvania. **VENEZUELA:** Oficina de Ingenieria Sociedad Anonima, Caracas.

Send for Publication R190

R31

"Closegang" construction



The design of Crabtree "Closegang" assemblies is as neat, orderly, and space-saving as any example from Nature's economy.

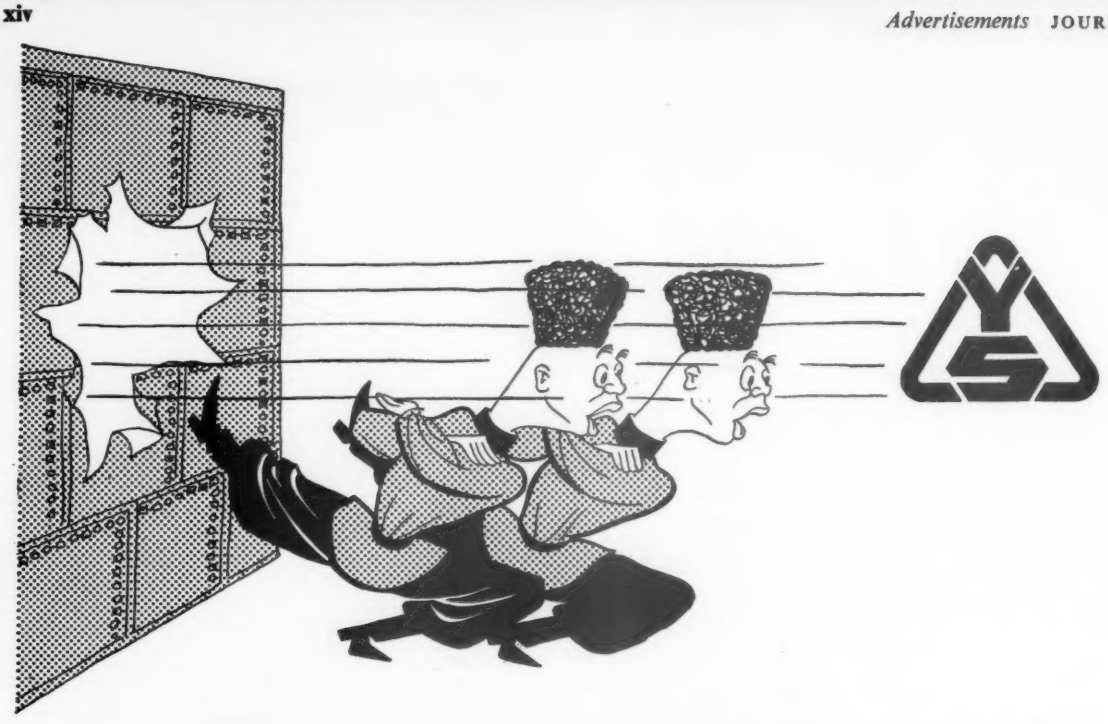
This range of 1 to 12 gang flush and surface mounting units provides for the interchangeable assembly, on B.S. 1299 fixing centres, of 5 and 12 amp. one and two way switches, intermediate switches, bell pushes and neon indicators. Architects, contractors and users alike agree on the high quality, ease of installation and handsome appearance of "Closegang" assemblies.

Details are given in Crabtree Publication No. 1197, copies of which are available on request.

CRABTREE

CLOSEGANG ASSEMBLIES

J. A. CRABTREE & CO. LTD., LINCOLN WORKS, WALSALL, STAFFS. C.778



Breakthrough by Yorkshire Switchgear

In the friendliest possible fashion, Yorkshire Switchgear punctured the Iron Curtain.

Fifteen metalclad boards, comprising one hundred and thirty-one units of Yorkshire Switchgear IVIO oil circuit breakers have been supplied for outdoor use and for heavy duty underground service in non-gaseous mines in Poland. Yorkshire Switchgear's high—and world-wide—reputation for heavy duty apparatus brought yet another substantial export order to this country.

Part consignment before leaving our factory.

Yorkshire Switchgear

& ENGINEERING CO. LTD.

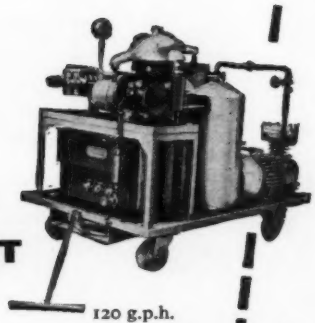
LEEDS, 6. TEL: LEEDS 57121/5

London: Grand Buildings, Trafalgar Square, W.C. 2 Tel: Whitehall 3530.
Also: Electro Mechanical Manufacturing. Co. Ltd., Scarborough.

ndh 11304

DE LAVAL CENTRIFUGAL

HIGH VACUUM SEPARATORS for INSULATING OIL TREATMENT



120 g.p.h.

A wide range of Stationary, Portable and Roadworthy Portable Units with capacities from 10—1200 g.p.h.

Specially designed high-efficiency equipments that ensure:—

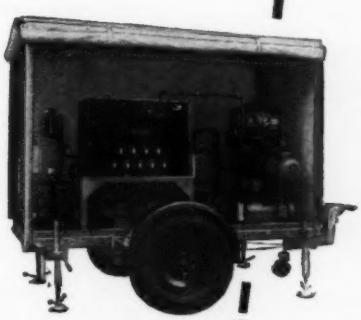
Maximum di-electric strengths, well above B.S.S. requirements for new oils, which are retained for longer periods.

Maximum extraction of free and dissolved moisture, air and solids, including colloidal carbon.

No back pressures or fall-off in throughput capacity.

Excessive quantities of water, sludge or solids which may be formed under abnormal conditions can be efficiently separated.

Minimum heating of oil under high vacuum, low running costs—no filter aids—simple and reliable operation.



800 g.p.h.

1200 g.p.h.

These De Laval equipments are now widely employed for:—

1 De-hydration and de-aeration of new oil when filling new transformers at site.
2 Drying out cores and windings of:—
(a) new transformers at site before they are put on load. (b) existing transformers whilst on load.
3 Improving the breakdown strength of oil in transformers on load.
4 Improving insulation resistivity of transformers.
5 Treatment of used transformer and switch oils in oil storage tanks.

OIL EQUIPMENT DIVISION

ALFA-LAVAL COMPANY LTD · GREAT WEST ROAD · BRENTFORD · MIDDLESEX

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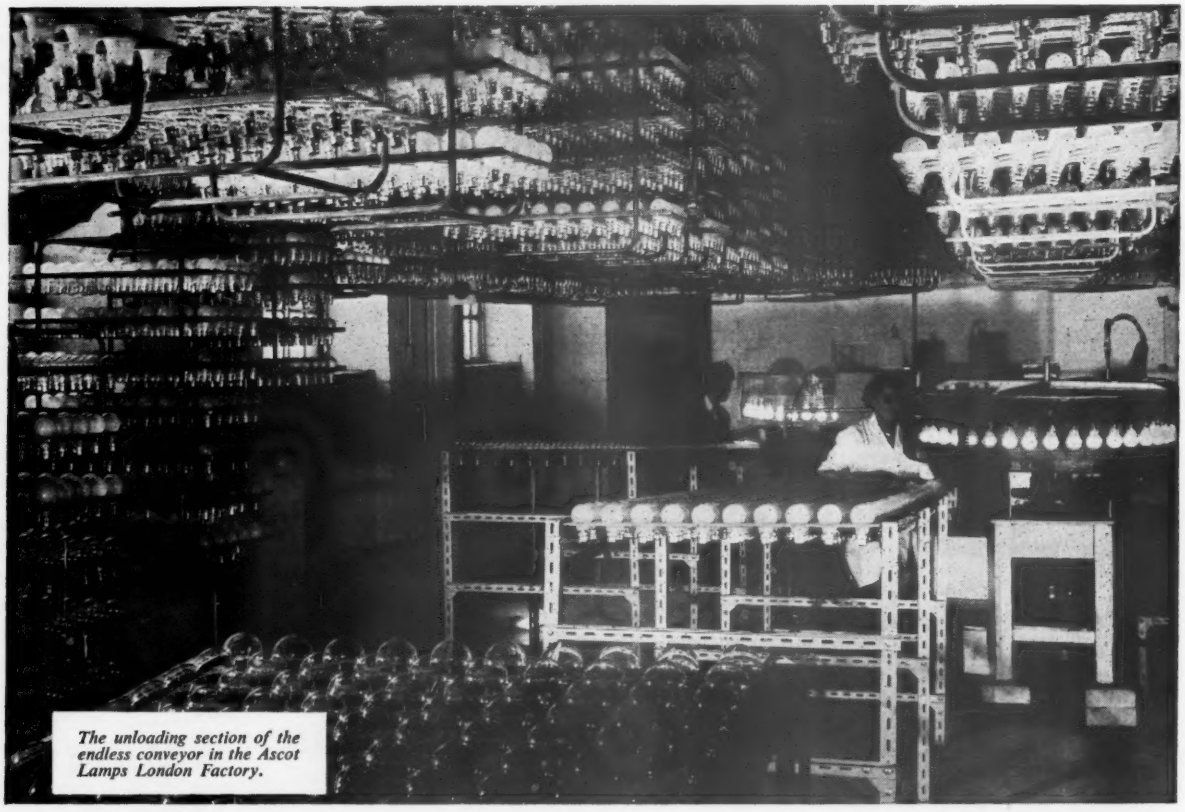
ASCOT SUCCEED IN PERFECTING NEW

TWICE-IN-24-HOURS TESTING SYSTEM



The unloading section of the endless conveyor in the Ascot Lamps London Factory.

NEVER BEFORE SUCH FLAWLESS LAMPS No longer do Ascot rely on the usual routine tests at the end of the production lines, when lamps are packed within minutes of manufacture.

Now, after their first comprehensive test, every Ascot lamp is stored for a full 24 hours in a huge mechanical overhead conveyor, and then put through the whole test cycle a second time. In this way even delayed action glass strains, so often the cause of early failures, are eliminated.

Ascot are the first manufacturers to achieve this great advance in lamp quality control and you can now rely, even more than before, on the flawless quality of Ascot lamps.

Write for full information on the full range of Ascot Lamps to:—

ASCOT

QUALITY LAMPS

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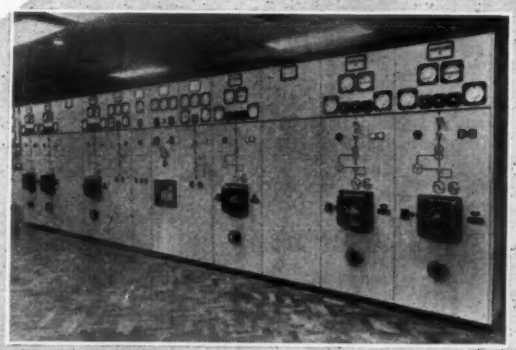
CLISSOLD 5183/4/5

WHG/L6

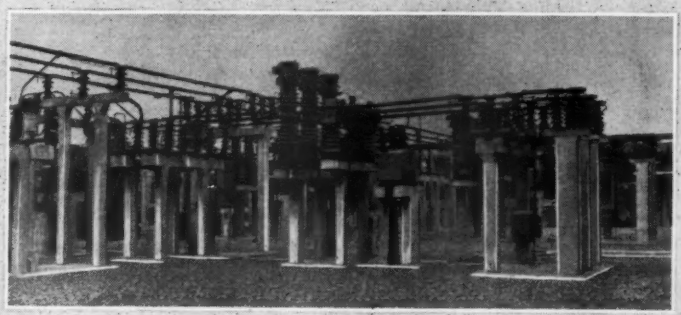
ROLLS-ROYCE LTD. DERBY. AERO ENGINE ALTITUDE TEST PLANT

WITH SWITCHGEAR SUPPLIED BY REYROLLE

The 33-kV 1000-MVA small-oil-volume switchgear and ancillary equipment controlling the supply to the six 22,000-H.P. compressor-motors was manufactured and installed by Reyrolle



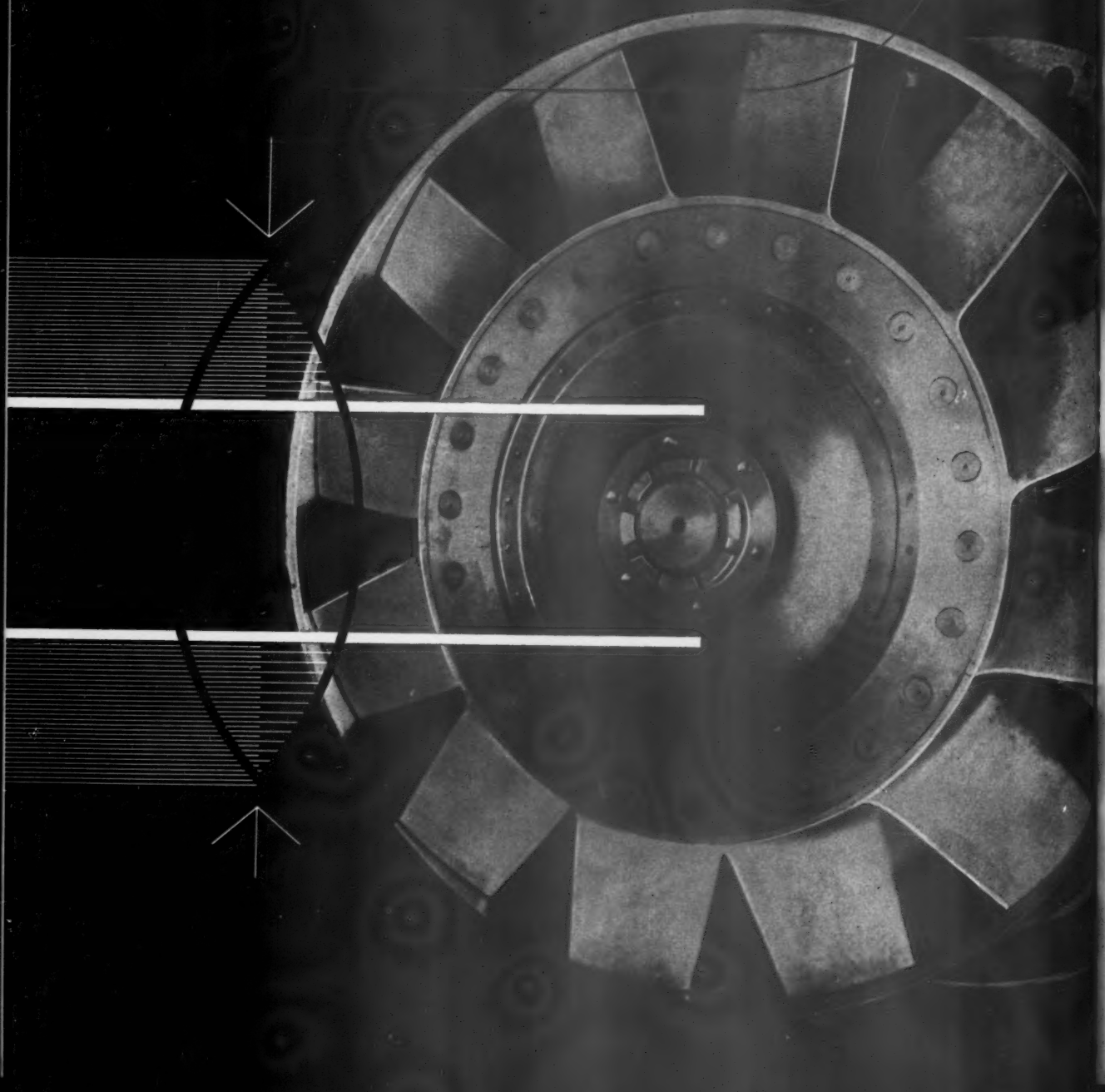
Photographs by courtesy of Rolls Royce Ltd.
Consulting Engineers: McLellan and Partners in association with Messrs. Merz and McLellan



Reyrolle

A. REYROLLE & CO. LTD. HEBBURN COUNTY DURHAM ENGLAND

APL blower oil or



TRIUMPHS OF SHELL RESEARCH . . . 3

or sentry-go at Bradwell...

The crucial points of the high pressure CO_2 coolant circuit at Bradwell will be the blower shaft seals. Every minute of every working day Shell APL blower oil will guard these escape points—being continually pumped into the seals and bearings, led away, purified and recirculated.

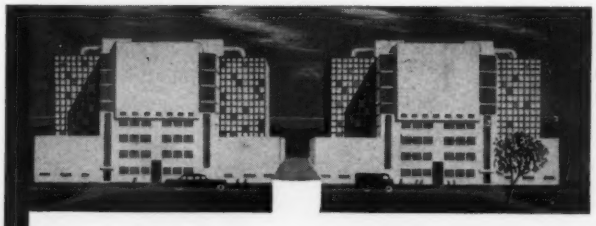
This very remarkable oil presents a two-way seal. Outwards, there is a minimum CO_2 loss as the oil has the lowest possible gas solubility. Inwards, in spite of the heat of the gas, oil vapour contamination is negligible thanks to the extremely low vapour pressure of the oil.

The research that went into APL blower oil is characteristic of the way Shell set about doing things. It was conducted at Shell's Research Centre at Thornton in close collaboration with the U.K. A.E.A. and the blower manufacturers. In the course of much fundamental research, a wide range of oils was subjected to vapour pressure and gas solubility tests in the laboratory. Selected oils from this range were used in the bearings and seals of a blower rig. In 1956, after four years of research, the finished product joined the Shell Atomic Power Lubricants range—marketed under the name of Shell APL 729. This oil has been in use at Calder Hall since the autumn of 1956.

The moral of the story is that Shell research is supremely applicational. The Centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubrication problem it pays to get in touch with your local distributor of Shell Industrial Lubricants.

The Research Story

Though the sealing action demanded of Shell blower oil is common in other industrial equipment such as hydrogen-cooled alternators, there were quite a few additional problems. It was necessary for the oil to have long life, low vapour pressure, low gas solubility, good thermal stability and high film strength —to be able to withstand high temperatures and to be resistant to all kinds of corrosive influences, including carbonic acid. The crux of the research was to combine all the above requirements into one oil, in order to minimise back diffusion of molecules which would contaminate the reactor.



BRADWELL NUCLEAR POWER STATION, AN ARTIST'S IMPRESSION.

SHELL

ATOMIC POWER LUBRICANTS

another proof of Shell leadership in lubrication

on guard

Extensible ring main, type KAA4 using two type DA4 oil switches

Switchboard with 800A and 1600A air circuit breakers in double tier formation

33kV

... night and day, year in, year out always ready for action. G.E.C. Switchgear has been proved by the most stringent tests at the works. But that's not all. This inherent reliability has been proved, time and again, at hundreds of installations all over the world.

There is Switchgear for every purpose in the G.E.C. range of equipment.

RING MAIN SWITCHGEAR
3.3kV to 11kV—up to 250 MVA at 11kV. With fault-making oil switches in extensible or non-extensible form.

INDOOR AIRBREAK SWITCHGEAR
50 MVA at 400/660V and up to 250 MVA at 3.3kV.

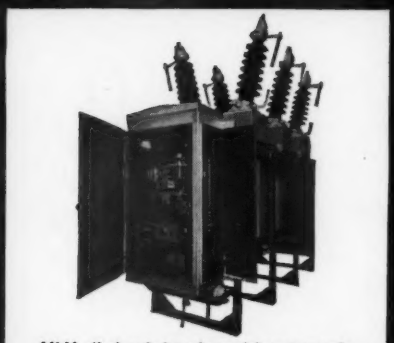
METALCLAD SWITCHGEAR
3.3kV to 33kV—up to 1000 MVA at 33kV. Units up to 250 MVA at 11kV available from stock.

OUTDOOR OIL CIRCUIT BREAKERS
11kV to 132kV—up to 5000 MVA at 132kV. Breakers up to 750 MVA at 33kV available from stock.

You are invited to ask for the Technical Descriptions of the above switchgear.

circuit

33kV, 750 MVA metalclad switchboard



66kV oil circuit breaker with pneumatic operating gear

132kV oil circuit breakers

G.E.C. power control equipment

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND.

HEAD OFFICE: MAGNET HOUSE KINGSWAY LONDON WC2

Closed Circuit T.V. in the City of London

Standard Telephones & Cables Ltd., on behalf of the British Post Office, have manufactured and installed a system of small diameter coaxial cables radiating from Capel Court in the heart of the City of London. They will be used for the speedy transmission of 'change information to individual Stockbroker's Offices on a Closed T.V. Circuit.

These cables are of a completely new type and are identical with those now being installed for high-quality telephony. Expanded polythene is used for the coaxial pair dielectrics and polythene for insulation of the control circuits and overall sheath. The cable is light, strong, impervious to moisture, easily handled and equally suitable for duct or aerial installation.

Like S.T.C., it has a major role in the future. For as closed circuit T.V. becomes more and more a part of the business scene, cables such as these will supply the means.

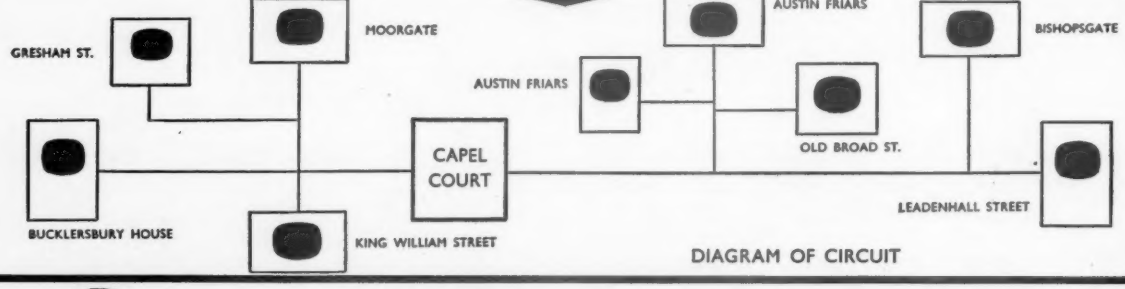


DIAGRAM OF CIRCUIT

Standard Telephones and Cables Limited

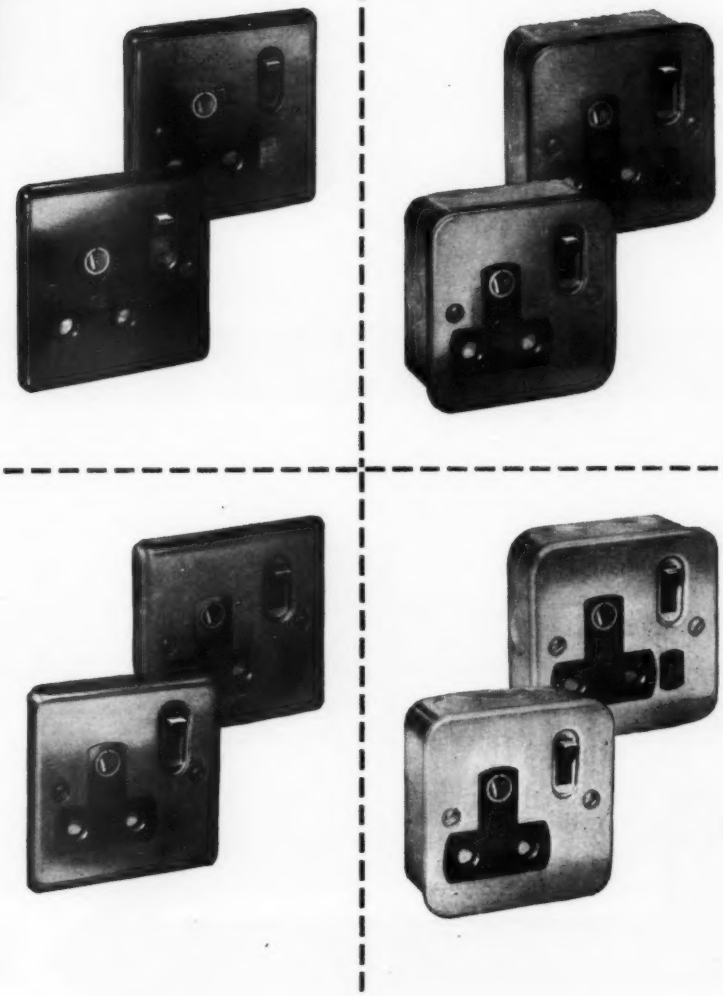
Registered Office: Connaught House, Aldwych, W.C.2

TELEPHONE CABLE DIVISION: NORTH WOOLWICH · LONDON · E.16

MK161 DHB

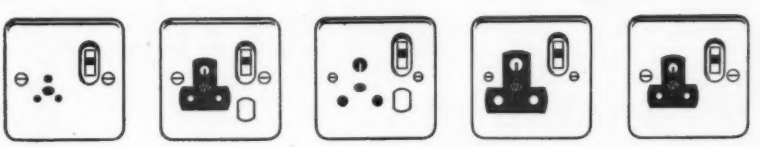
STANDARDISE WITH MK

An important new range of Round-Pin Switchsocket-outlets



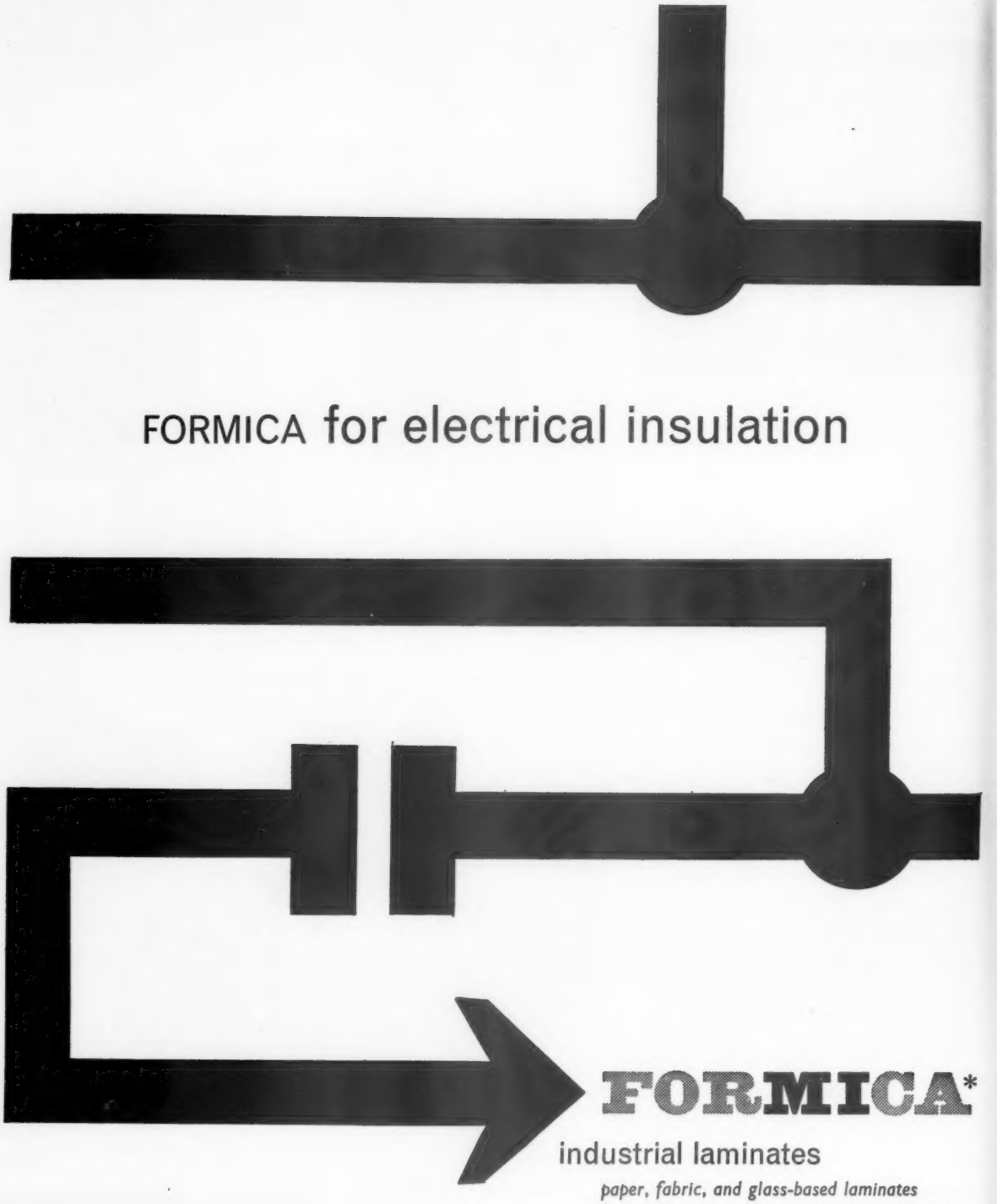
This versatile new range consists of interchangeable designs with standard 2¾" fixing centres. Flush patterns are therefore suitable for mounting in all standard boxes with 2¾" centres. This is a decided advantage enabling stocking, ordering, installation and maintenance to be simplified. Surface mounting units have steel plates finished aluminium stove enamel or brass plates finished BMA or matt chrome. Flush mounting patterns are available moulded brown or ivory or with brass plates finished BMA or matt chrome.

All ratings . . . 2, 5 and 15 ampere — all of the same dimensions. All with new recessed switch handles. All with or without Pilot-lamps. One standard Box for flush mounting, with 2⅜" fixing centres. Leaflet 248 available on request.



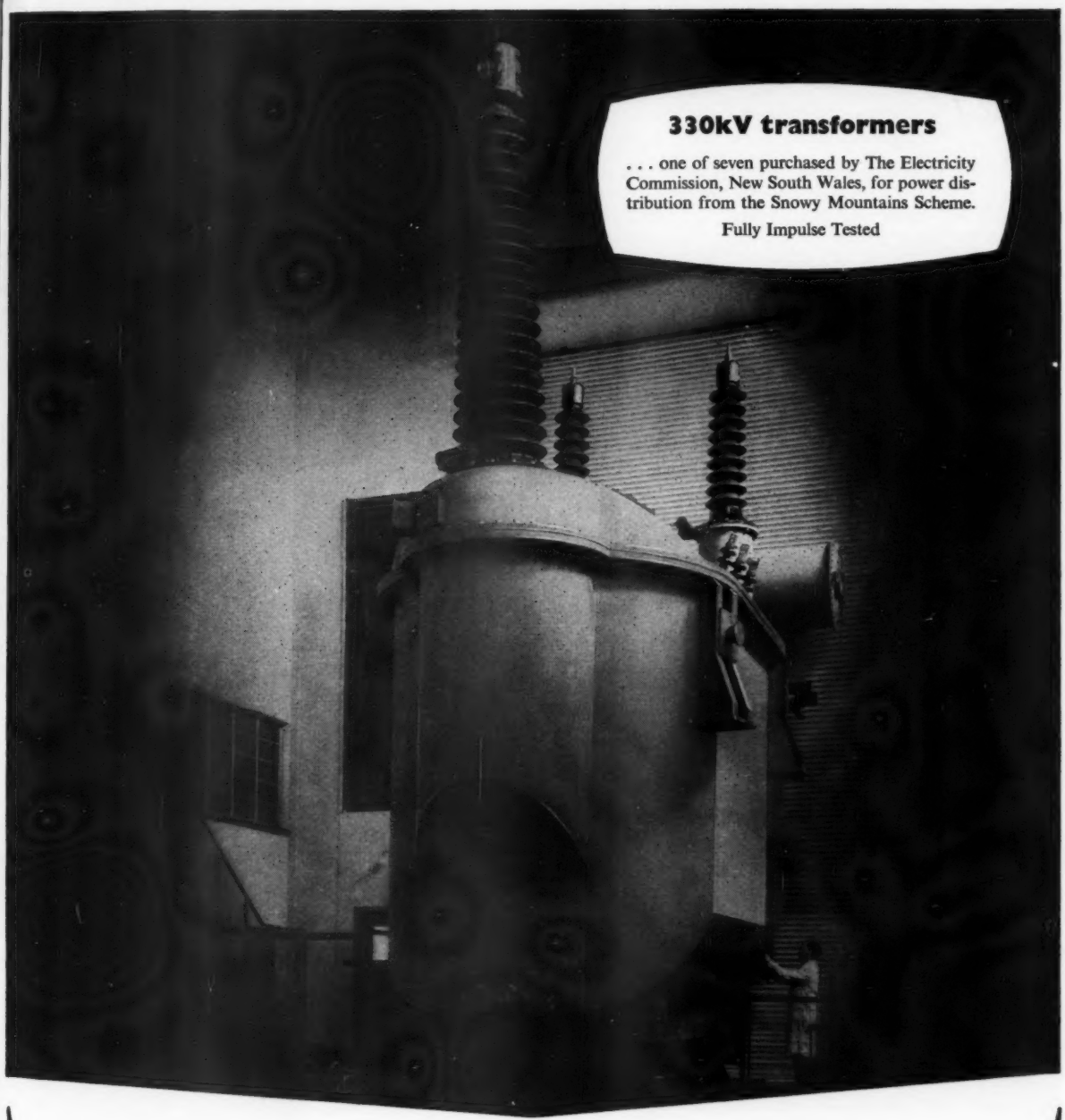
MK . . . the mark of leadership

M. K. Electric Limited, Wakefield Street, London N.18 Edmonton 5151



FORMICA LTD, DE LA RUE HOUSE, 84/86, REGENT STREET, LONDON W.1

*FORMICA *is a registered trademark*


330kV transformers
. . . one of seven purchased by The Electricity Commission, New South Wales, for power distribution from the Snowy Mountains Scheme.
Fully Impulse Tested

'ENGLISH ELECTRIC'

transformers

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2.

Transformer Department, Stafford

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

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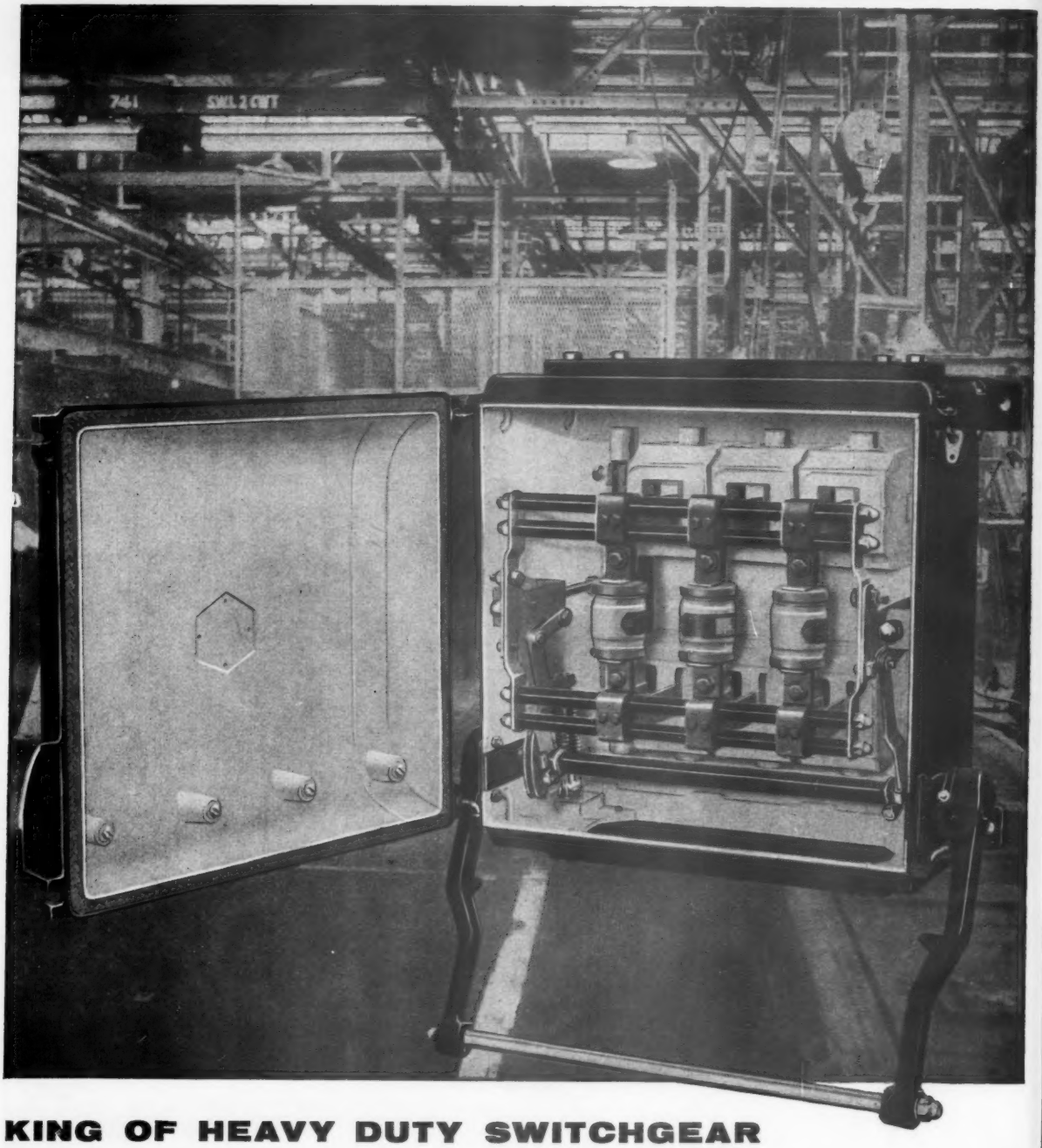

KING OF HEAVY DUTY SWITCHGEAR

MIDLAND ELECTRIC
MANUFACTURING
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TYSELEY
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MEM

MEM 'GLASGOW-REX' H.R.C.

THERE MUST BE few electrical engineers anywhere in the world who are not familiar with the "Glasgow-Rex" Switches and Fused Switches. The world-wide reputation gained by this range is well deserved. The quality is superlative.

Designed for heavy duty on large power and lighting installations "Glasgow-Rex" is available in ratings from 30 to 300 amps, 500 volts, in D.P., T.P., and T.P.N. patterns.

The fuse switches are fitted with "Kantark" H.R.C. Cartridge Fuse Links rated at the carrying capacity of the switch, and will clear the heaviest fault currents without risk of damage.

Bearing in mind that H.R.C. Cartridge Fuse Links are included, prices are most highly competitive.

Send for List No. 340 describing the "Glasgow-Rex" and other M.E.M. switchgear.

Principal Products

of BRITISH DRIVER-HARRIS

Furnace Elements Nickel alloys for longest life at high temperatures; for certain special atmospheric conditions; for furnace constructional work.

Domestic Appliances Nichrome* V for longest life at temperatures up to 1,150°C; Nichrome* for temperatures up to 950°C; other alloys for less exacting conditions.

Thermocouples T1/T2 alloys (nickel-chromium and nickel-aluminium) for temperatures up to 1,100°C are identical with the best-known wires formerly imported. Also Special Advance* (nickel-copper) for use with copper or iron. Matched Advance*/Iron wires are also available.

Radio and TV Field Pure nickel and nickel-manganese and other nickel alloys, for cathodes, anodes, grids, filaments, supports, glass-metal seals, and other applications.

Electronics Applications Nickel-containing alloys for instrumentation uses in vital scientific categories involving highly specialised and often critical requirements.

Lamp Industry Nickel-manganese for supports, grids, and lead wires. Glass-sealing alloys to suit different types of glass.

Spark Plugs Alloys of the correct physical properties and temper to meet manufacturing requirements in centre and side electrodes; and such as special strip for stamping out multi-point discs for aircraft plugs.

Superfine wires Very fine wires from 0.002 in. (0.05 mm.) downwards in various alloys, such as Nichrome* V, Nichrome*, Karma*, Advance*, and Pure Nickel. Available in bare, enamelled, or enamelled and silk-covered, finishes.

Thermostatic Bimetal For domestic and industrial applications. In all standard types, and in sizes to meet your needs.

BRITISH DRIVER-HARRIS CO LTD

CHEADLE HEATH, CHESHIRE

GOLDEN JUBILEE 1958

* REGD. TRADE MARK

These photocells give you the simplest photo-electric control possible

Photo-electric control with the Mullard ORP11 and ORP90 cadmium sulphide cells is the simplest possible because a photocell and relay form the complete circuit.

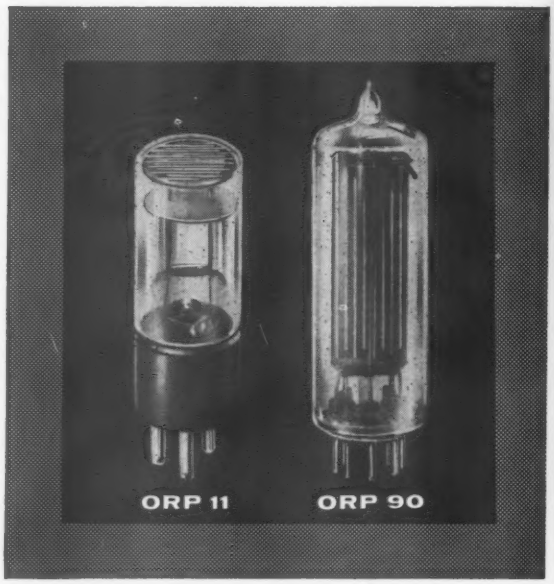
The unusual combination of high current capacity and extreme sensitivity of these Mullard cells enables robust relays to be operated direct—amplifiers are unnecessary.

Both cells can be operated from either a.c. or d.c. supplies, they are inherently rugged and have a wide range of applications in industry.

The usable response extends through the entire visible spectrum to the near infra-red.

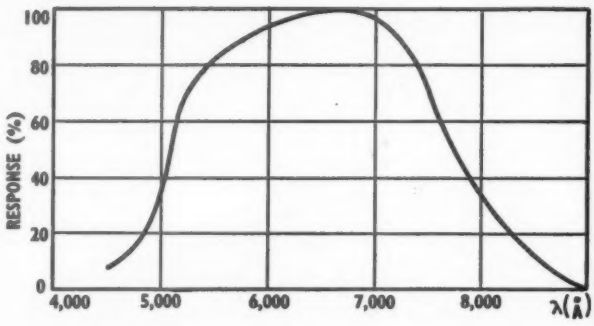
The ORP11 differs from the ORP90 chiefly in being "end-viewing" and having a somewhat smaller photocathode area. This type of photocell is made available to simplify mounting problems encountered in certain applications—particularly in flame failure detectors in oil fired furnaces.

Data sheets giving further information are readily available from the address below.



ABRIDGED DATA

	ORP 11	ORP 90
Required direction of incident light	End-on	Side-on
Area of photo-element	1.25 sq. cm.	2.9 sq. cm.
Average cell current at 10V d.c., 5 foot candles and lamp colour temperature 2,700°K.	6mA	6mA
Maximum ultimate dark current at 100V d.c.	5 μA	< 2.5 μA
Maximum cell dissipation at 25°C.	200 mW	600 mW
Spectral response	Same for both cells—see curve.	



Mullard Limited

Mullard House, Torrington Place, London, W.C.1

Telephone: Langham 6633

Mullard

GOVERNMENT AND INDUSTRIAL VALVE DIVISION

MVT 360a

THEY SET A STANDARD

A Roman villa, A.D. 400

DURING their occupation of Britain (A.D. 50—A.D. 410), the Romans built themselves homes of great beauty. They brought from Egypt the art of brick-making —an art which disappeared when the Dark Ages came, and which was not recovered in England until the 13th Century. In architecture, as in many other fields, the Romans set a standard which few have equalled since. In cable making too, standards are of vital importance. For over 100 years members of the Cable Makers Association have been concerned in all major advances in cable making. Together they spend over one million pounds a year on research and development. The knowledge gained is available to all members. This co-operation has contributed largely to the world-wide prestige that C.M.A. cables enjoy, and it has put Britain at the head of the world cable exporters. Technical information and advice is freely available from any C.M.A. member.

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* *C.M.A. Trade Marks for Mains Cables only*

Insist on a cable with the C.M.A. label

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CMA 22

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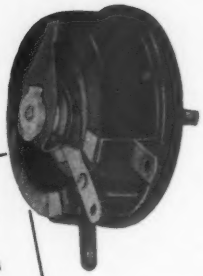
TRANSFORMERS
Exact voltage control
6 standard models
250VA — 2.5 kVA

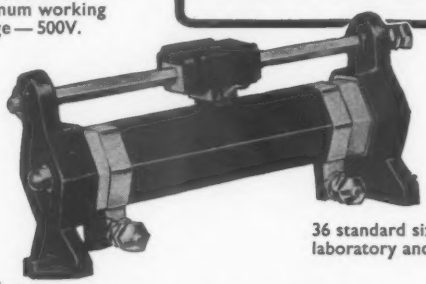
SEALED
POTENTIOMETERS
— 1 and 5 watt models
Proofed against Dust,
Fumes, Climate etc.
Maximum working
voltage — 500V.

BERCO

VOLTAGE & CURRENT CONTROL EQUIPMENT

BERCOSTAT RHEOSTATS
Accurate — tough — compact.
8 sizes from 25-500 watts.





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36 standard sizes for
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'IMPERIAL'

HEAVY DUTY CAST ALUMINIUM INDUSTRIAL LIGHTING UNIT

WEATHERPROOF, VAPOUR, DUST AND CORROSION RESISTANT

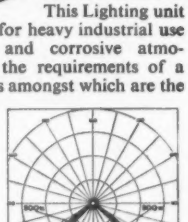
For use with 500 Watt and 300 Watt Tungsten Filament Lamps or 250 Watt and 400 Watt Type MA/V . . . H.P.M.V. Lamps.

SPECIFICATION OF R96646 "IMPERIAL" UNIT

Body and bezel cast aluminium alloy (B.S. LM-6 M Alloy) "Alacrom" pre-treated stoving oxide chromate priming coat and corrosion-resistant stoved grey finishing coat. Bezel attached to body by fully floating hinge and clamped by three hinged bolts and wing nuts. All these fastenings of stainless steel. Gasket joint between bezel and body is by rectangular section rubber compound ring sealed in body with free face of rubber leaded to prevent sticking after long periods of compression. Reflector of spun semi-specular finish anodised aluminium of carefully designed contour to give correct light distribution and high efficiency. Top entry tapped one inch conduit. Domed heat-resisting glass retained internally by safety screws and cemented into bezel by plastic cement to accommodate expansion of glass and metal. Porcelain G.E.S. skirted lampholder attached to pair of lugs cast into the body to give correct light centres for either 500 Watt or 300 Watt Tungsten Filament Lamps. A smaller unit to a similar specification is available for 150/200 Watt Tungsten Filament Lamps.

APPLICATIONS

This Lighting unit has been designed for heavy industrial use including humid and corrosive atmospheres. It meets the requirements of a variety of industries amongst which are the following: Gas Works, Chemical Works, Steel Works, Cargo Loading Lights, Docks and Harbours, Plating Shops, Railways, high humidity areas. It is suitable for outdoor and indoor use.



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AP83

'Welvic' covered cables in the Royce Electric Panel.

When Duratube and Wire Ltd. use p.v.c. to cover cables

they use I.C.I. 'Welvic'

WHEN you are planning to use p.v.c. use I.C.I. 'Welvic' p.v.c. compounds. 'Welvic' is backed by the full force of I.C.I. research and technical service—and that service is available to *you*. If you would like to know anything about the range and properties of p.v.c. manufactured by I.C.I. have a word with one of this Company's Sales Offices. They'll be glad to hear from you.

One of the most popular uses of p.v.c. is in covering cables. Here, cables made by Duratube and Wire Ltd., and covered with 'Welvic' are shown in the Royce Electric Panel made by Brentford Transformers Ltd.

'WELVIC'

'Welvic' is the registered trade mark for the p.v.c. compounds manufactured by I.C.I.

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ASSEMBLED IN 30 SECONDS
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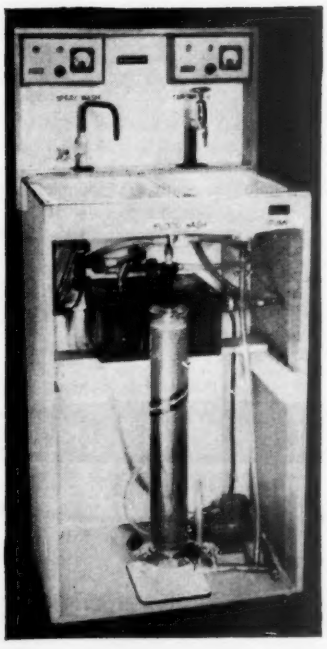

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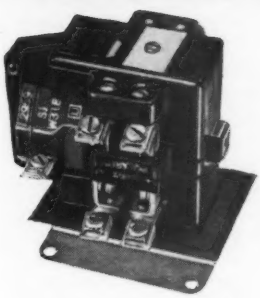

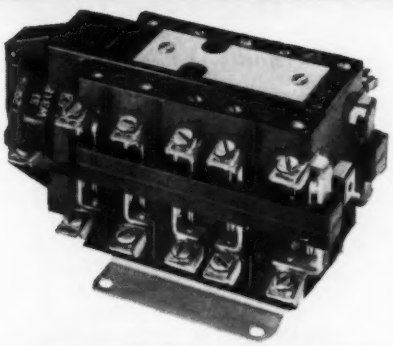

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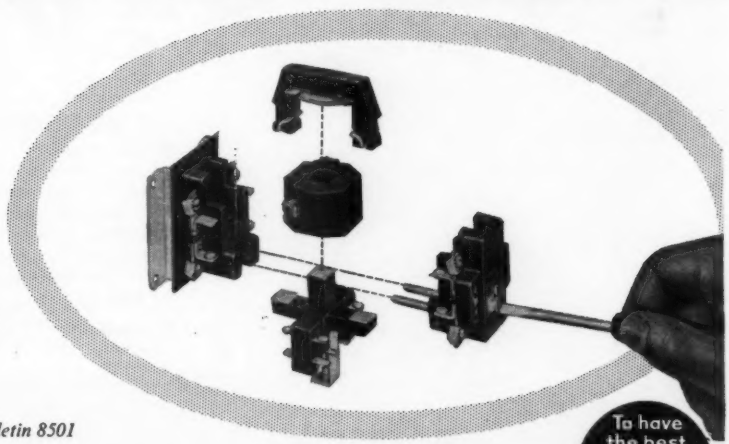

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WESTON MOVING COIL RELAYS

Illustrated is the Model S170. Other types include the Model S124, a magnetic contact relay which operates with a minimum power input of 0.004 microwatt and the Model S115, a miniature relay, which functions as an "on-off" switching relay.

The simplicity and reliability of relay control for a wide variety of applications has led to the ever increasing use of Weston Moving Coil Relays.
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SIMPLE EFFICIENT

Speech communication

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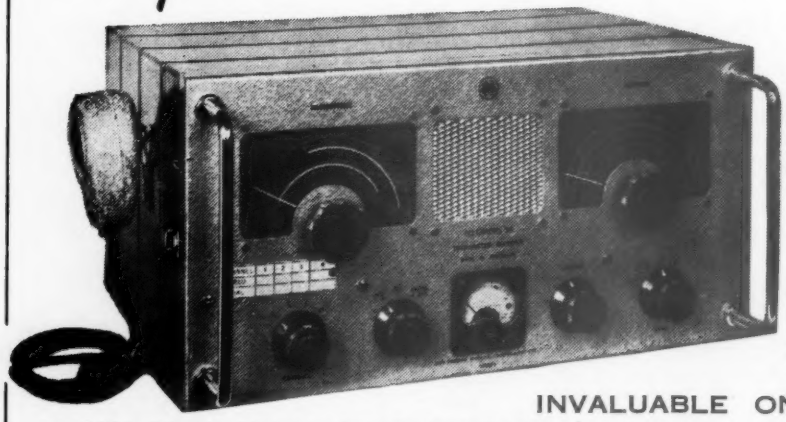
RADIO TELEPHONE



SIMPLICITY
Only six controls, no technical skill required.

SIZE
In one attractively finished case, 9" x 16" x 20".

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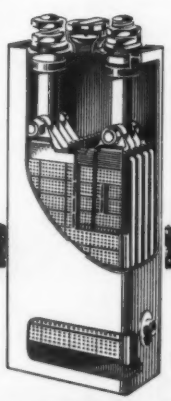

The Nife Switch Tripping Unit can be used, in addition, for any other application involving intermittent discharges. You'd like to know more about it?

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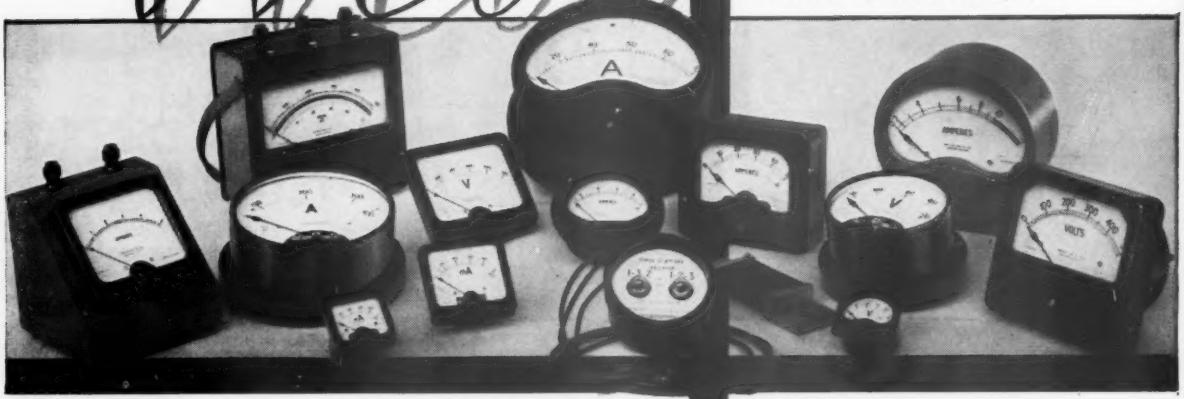

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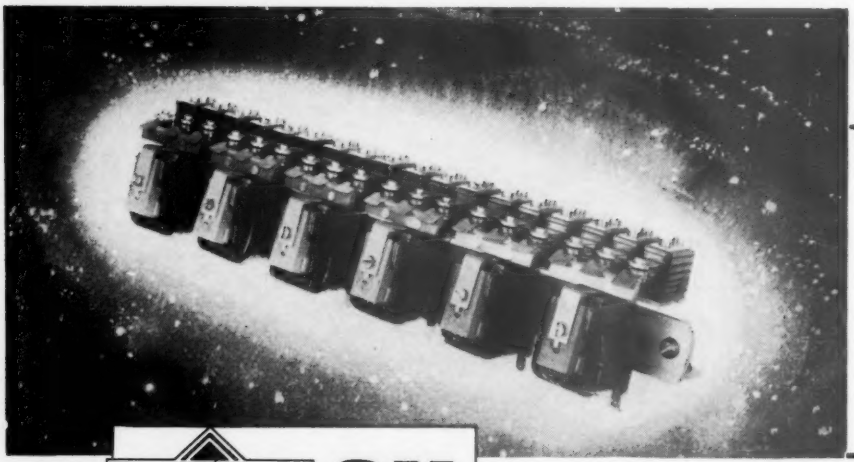

Multiple contact relay type SMF Contacts up to 3 pole DT Rating 2A 250v AC

Mercury switch relay type SMQ Contacts up to SPDT Rating 10A 250v AC

This rack of relays shown left occupies a length of only 9 inches.

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save up to 50% in cost and space

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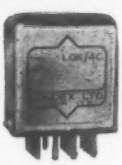

Enclosed plug-in relay LOK 2 models available DPDT or 4 pole DT Rating 2A 250v CAC

Micro-switch relay type SMM Snap action SPDT Rating 15A 250v AC

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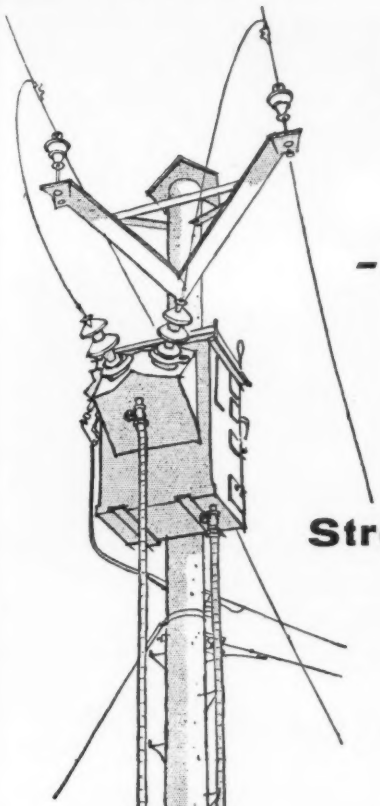
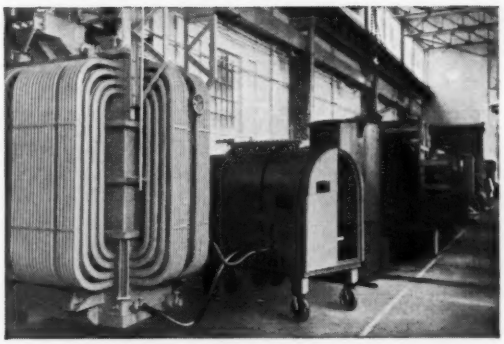


in the field

-and in the factory



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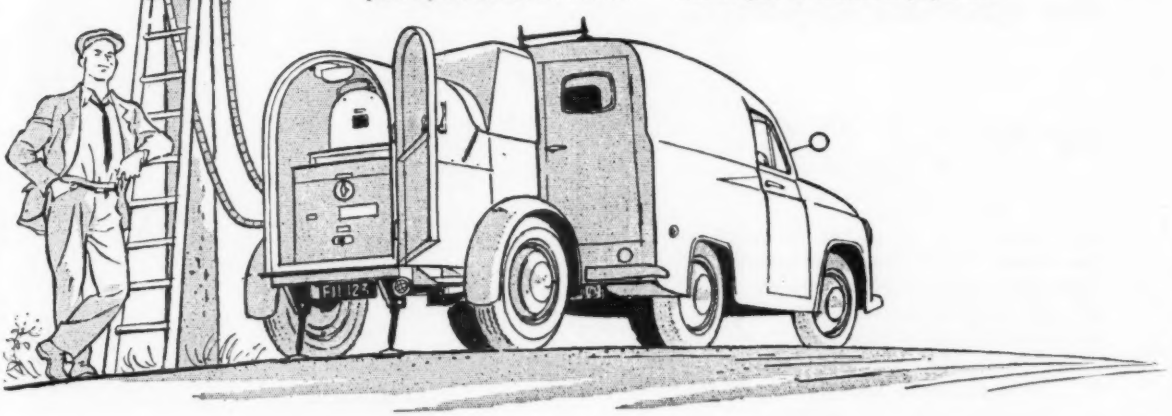

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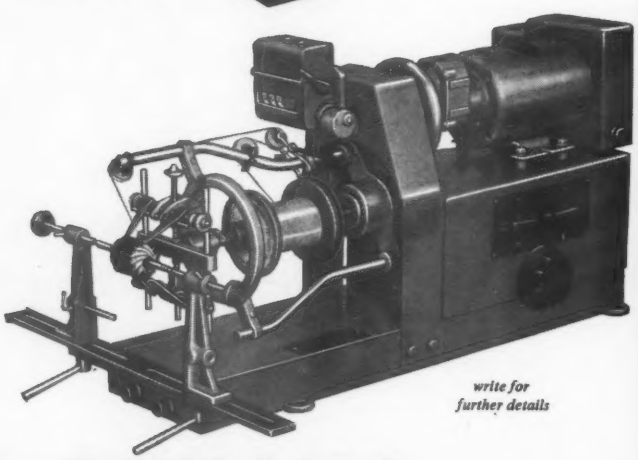

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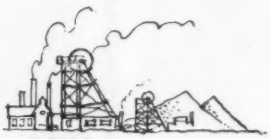

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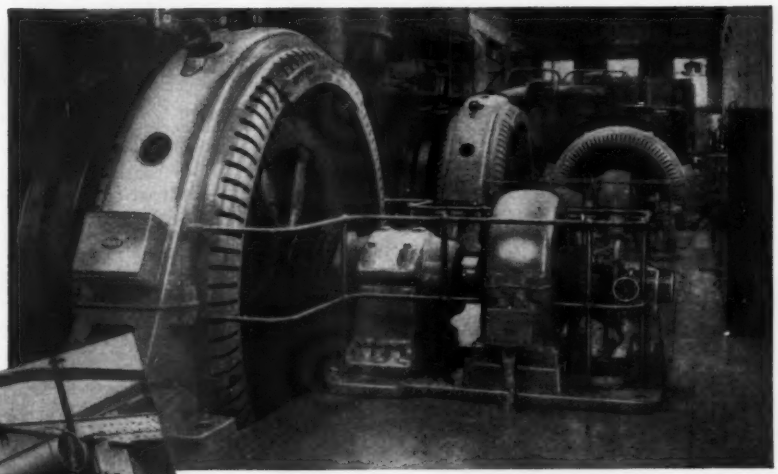

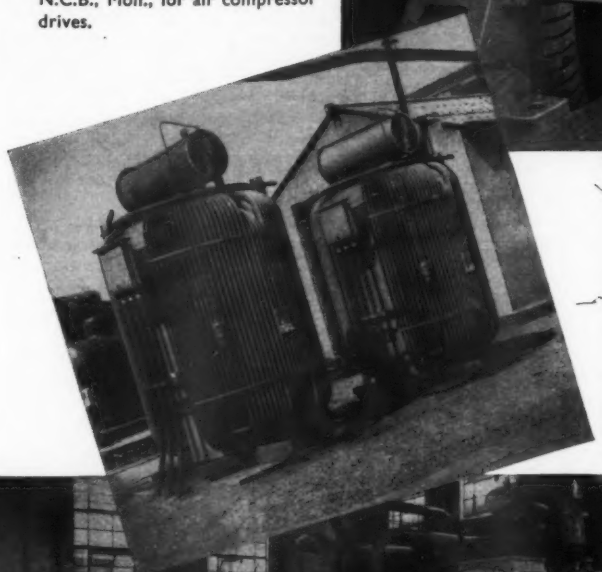

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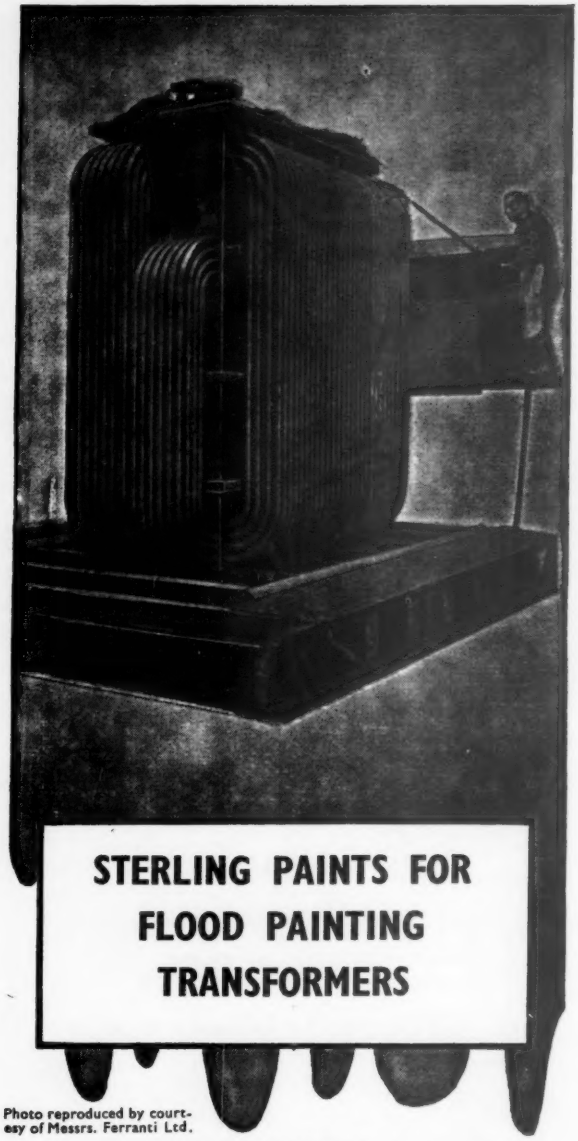

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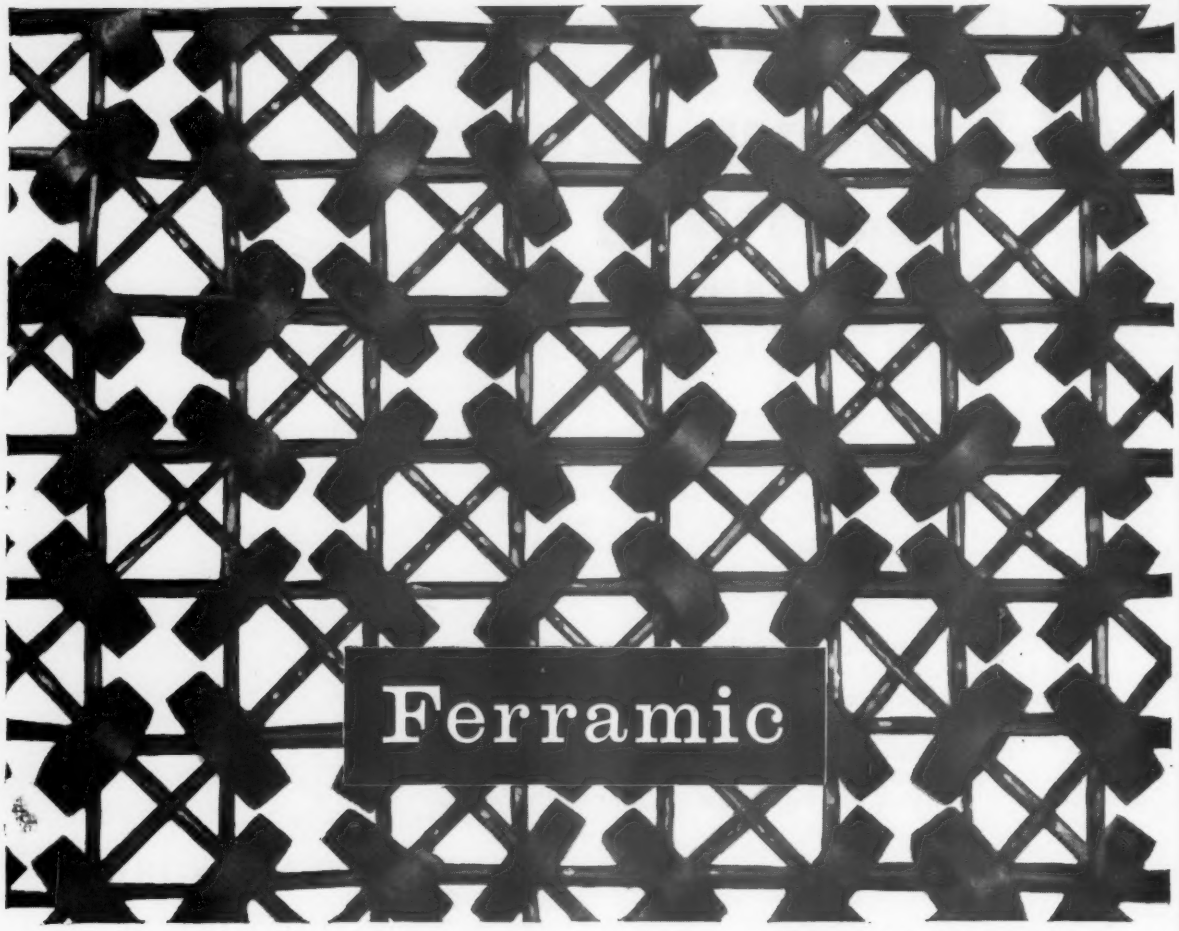

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